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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 98, April 20. 5754

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See Advertisement page 88. 5707

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See Full Page Advt. page 58, April 6.

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See Advertisement page 29, April 13. 2402

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MONOMETER MANUFACTURING CO., LTD.,
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See Advertisement page 56, April 13.

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NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

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See half-page Advertisement page 76, April 20.

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Founded 1854 by Sir W. FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5864

IN THE HIGH COURT OF JUSTICE. 1917 C. No. 033.
CHANCERY DIVISION.
MR. JUSTICE BYE.
In the Matter of CREED & COMPANY, LIMITED (and Reduced),
and
In the Matter of the COMPANIES' ACTS, 1908 and 1913.

Notice is Hereby Given

that a Petition for Confirming a Resolution reducing the capital of the above Company from £130,000 to £80,000 was, on the 5th day of April, 1917, presented to His Majesty's High Court of Justice, and is now pending; and that the list of creditors of the Company is to be made out as for the 23rd day of May, 1917.

HAIR & CO.,
of 7, St. Mildred's Court,
Poultry, E.C., G 617
Solicitors to the Company.

Inst. C.E, Inst. Mech. E. and

all Engineering Exams. Correspondence Coaching by practical Engineers. I.C.E. Successes 282 out of 310; two Bayliss Prizes, "Proxime Accessit," special features for foreign candidates. Write for booklet &c.—Address, G 579, Offices of ENGINEERING.

TENDERS.

Tenders are Invited for Four

Babcock & Wilcox WATER-TUBE BOILERS with Automatic Chain Grate Stokers. Working pressure 210 lbs. In excellent condition, each evaporates 15,000 lbs. per hour. Can be seen working daily, Mondays to Fridays, Ten a.m. to Twelve noon, and Two p.m. to Four p.m. at the Stuart Street Electricity Works, Bradford, Manchester.

Tenders to be addressed to the CHAIRMAN OF THE ELECTRICITY COMMITTEE, Town Hall, Manchester, and be delivered not later than Ten o'clock a.m., on Friday, the 11th May proximo.

G 626

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of

the Whole or any part of 119,660 Shares of £5 each, fully paid, in SIEMENS BROTHERS & COMPANY, LIMITED, vested in him as Custodian by an Order made by the Board of Trade, in pursuance of Section 4 of the Trading with the Enemy Amendment Act, 1916, and dated 9th August, 1916.

The issued capital of the Company consists of 120,000 Shares of £5 each, fully paid.

The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.

The purchasers will also be required to satisfy the Public Trustee as to their financial and technical ability to carry on the business of the Company as efficiently as heretofore, or otherwise to the satisfaction of the Government.

A report upon the Company's operations and affairs has been prepared by the Company, in conjunction with the Company's Auditors (Messrs. PRICE, WATERHOUSE & Co.), and with Messrs. TURQUAND, YOUNGS & Co. Copies of this report can be obtained, subject as hereinafter mentioned, together with copies of Company's accounts up to the 31st December, 1915, on written application to the Public Trustee, Kingsway, W.C.

All applicants will be required to satisfy the Public Trustee as to any matter which he may think fit to investigate before copies of such Report or accounts will be supplied.

Intending Tenderers who desire to inspect the property of the Company, should apply to the Public Trustee for an authority to do so.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Thursday, the 14th June, 1917 (NOT APRIL 2ND, AS PREVIOUSLY ADVERTISED), at Twelve o'clock Noon, and marked on the envelope, "Tender, Siemens Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith.

Forms of Tender can be obtained from the PUBLIC TRUSTEE.

Dated this 5th day of February, 1917. 5643
C. J. STEWART, Public Trustee,
Custodian for England and Wales.

APPOINTMENTS OPEN.

Works Manager Wanted in

Manchester district. Speciality, Electrical Crane and Lifting Machinery. Previous experience in this particular line not absolutely necessary, providing the applicant is up-to-date in the management of men and machines. Firm in control of and engaged on Class "A" work carrying highest priority. Permanent and progressive position for a man showing good results. State fullest particulars in strictest confidence.—Address, G 611, Offices of ENGINEERING.

Chief Inspector of Aeroplane

Parts, for Aviation Works near London. Good man required. Experience of A.I.D. requirements an asset. No person resident more than 10 miles away or already on Government Work need apply. State age, salary and qualifications. — Write, Box 562, SAMSON CLARK & Co., Ltd., 56, Gt. Portland St., W 1. G 614

Works Manager Wanted

IMMEDIATELY for Controlled Works presently chiefly occupied on Brass work for Munitions, but whose normal trade is the manufacture of vertical Cast-Iron Pipes. Must be first class Engineer and good organiser of labour (chiefly semi-skilled). Six o'clock man. State age, experience, salary required.—BRASS, WILLIAM PORTEOUS & Co., Advertising Agents, Glasgow. G 628

Buyer, for Engineering Works

near London. Technical knowledge essential. Permanency for good man. Particulars of experience, age, and salary. No one engaged on Government work, or resident more than 10 miles away, need apply. — Address, G 641, Offices of ENGINEERING.

Chemical Engineer (Manager)

WANTED, by Controlled Firm for works in Lancashire. Permanency.— State age, salary, experience and organising ability, to BOX B 38, LEE & NIGHTINGALE, Liverpool. G 631

Gentleman Required to Take

entire CHARGE of Drawing Office, Engineering Estimating Department and the Designing of New Plant, for important chemical firm.

Must be a thoroughly competent man with highest qualifications and very large chemical engineering experience.

A really important position is open and a large salary will be paid.

Applications should be addressed to the

BRITISH CELLULOSE & CHEMICAL MANUFACTURING COMPANY, LIMITED,
Spondon, near Derby.

G 557

Gentleman Required to Take

charge of Drawing and Estimating Office for the design of new plant, repairs and extensions for large works. Must be thoroughly competent man, capable of supervising erections and control of men, and with good general engineering experience. No one already employed on Government work will be engaged.—Applications, which will be treated in confidence, should state age, salary, and give full details of experience and qualifications to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 634.

Wanted, a Well-Educated

MAN, 40 to 45, to act as General Assistant to the Managing Director of a large Coal, Iron and Steel Company employing many thousands of workpeople in this country. It is essential that applicants—who should have had preferably an engineering training—should have spent their whole working career in a similar organization. Substantial salary, with excellent prospects, for the right man. Applications will be treated in the strictest confidence, and destroyed after the successful candidate is appointed.—Address, G 578, Offices of ENGINEERING.

Shop Foreman for Electrical

Switchgear factory; good disciplinarian, Six o'clock man, able to direct and control both male and female labour, with good knowledge of manufacturing processes and shop practice. Permanent position and excellent prospects for right man. —State fully experience, qualifications and salary, to your nearest EMPLOYMENT EXCHANGE, quoting this paper and No. A 3185. No one on Government work should apply. G 647

Wanted, Foreman over 50

Machines and Lathes, large and medium; capable of getting maximum output. State age, present and previous employers, and wages. No man on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 655

Assistant Engineer Wanted

for Works in East Anglia; must be capable of running water tube boilers, steam turbines, and repairs and maintenance of machinery. A knowledge of H.-T. alternating current preferable. A good opening for a capable young man.—Apply, stating age, experience and salary expected, to your nearest EMPLOYMENT EXCHANGE, quoting No. A3167. No person already on Government work will be engaged. G 589

Wanted (for Yorkshire), Two

MEN, used to operation and maintenance gas producers and gas shell furnaces (preferably Wincott's). No one now employed on Government work will be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 646.

Wanted, Immediately, for

Controlled Establishment, DRAUGHTSMAN-CLERK of WORKS, for Extension of Blast Furnaces in the Midlands.

Applicants must have had first-class experience in the building of furnace casings, hoists, mains, &c.

State when could be at liberty, and salary expected.

Address, G 582, Offices of ENGINEERING.

Architect's Assistant Wanted.

Artistic Draughtsman and some knowledge of quantities, for controlled firm. Ineligible, or Class C.—Apply, stating salary required, to your nearest EMPLOYMENT EXCHANGE quoting No. A 3157. No person already on Government work will be engaged. G 657

Consulting Engineer Requires

an ASSISTANT with a knowledge of structural work, mining and cement making machinery. —Address, fully stating qualifications to G 525, Offices of ENGINEERING.

A Situation is Vacant for a

PLAN RENDERER in an Engineer's office in London. A knowledge of indexing is desirable. Preference given to a discharged soldier.—No one employed on Government work, or resident more than 10 miles away will be engaged.—Write, in own handwriting, to X. Y., care of McCORQUODALE and Co., St. Thomas' Street, Southwark, S.E. 1. G 648

Wanted, for War Work,

Experienced DRAUGHTSMAN with thorough knowledge of electrical work. State experience and wages.—Apply, in writing, to COMMANDING OFFICER, Hawkcraig, Aberdour, Fife. G 638

Draughtsman, Mechanical,

REQUIRED, used to designing and laying out colliery plant.—Apply by letter stating age, experience and salary required, BARBER, WALKER AND COMPANY, Eastwood Collieries, near Nottingham. G 563

Draughtsman (Ineligible)

REQUIRED for Admiralty work.—Apply by letter stating experience, training, age, wages required to C. Q., care of STREETS, 30, Cornhill, E.C. 3. No one at present employed on Government work, or living more than 10 miles away will be engaged. G 643

Wanted, Draughtsman for

the mechanical design of large electrical direct current machines. Nobody engaged on Government work will be accepted.—Write or apply to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2031. G 457

Wanted, Immediately for

urgent Government work, FIRST-CLASS DRAUGHTSMEN accustomed to steel buildings, bridges and heavy constructional work. No person already employed on Government work will be engaged.—Apply, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 565.

Required, Draughtsman for

London Engineering Works. Experience of marine engineering or large casting work essential. Capable man required. No applicants residing outside radius of 10 miles, or already employed on Government work, can be engaged.—Please write, stating age, experience, and salary required to G 610, Offices of ENGINEERING.

Jig and Tool Draughtsman,

for Aeroplane Works near London. Experience in shop lay-out an asset. No person resident more than 10 miles away or already on Government work need apply. State age, salary and experience.—Write, BOX 585, SAMSON CLARK'S, 56, Great Portland Street, W. 1. G 613

Wanted, for Aeroplane Works

near London, One Senior and One Junior Jig and Tool DRAUGHTSMAN, with some experience of Press Tools. No one employed on Government work or resident more than 10 miles away will be engaged.—Address, stating experience, wages required, &c., G 632, Offices of ENGINEERING.

Draughtsman Required,

accustomed to the design and construction of metal melting furnaces, hardening and annealing furnaces, gas and oil fired. No person already employed upon Government work will be engaged. —Applicants must apply to their nearest EMPLOYMENT EXCHANGE, mentioning ENGINEERING and G 631.

Draughtsmen.—Several Mechanical DRAUGHTSMEN for turbine

design and detail, WANTED, by a Controlled firm in the Midlands. Liberal salaries and bonuses to suitable men. No man on Government work need apply.—Apply, stating salary, and when able to commence to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 3139. G 583

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DRAUGHTSMAN REQUIRED by controlled firm. One with some oil engine experience preferred, but not essential. No one at present on Government work will be engaged. Must be capable and energetic. Send full particulars of experience, State age and salary.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and quoting No. A3153. G 656

Two or Three Capable

DRAUGHTSMEN WANTED immediately, by a well-known firm in the Midlands, for urgent Government work. Experience in vertical internal combustion engines for marine work (both of the Diesel and two-stroke type) is essential. No one already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 510.

Wanted, by Railway Company

in London, DRAUGHTSMAN (ineligible) with experience of Railway Electric Signalling.—Address, G 637, Offices of ENGINEERING.

Required, at Once, for Government

work, a few good DRAUGHTSMEN. Engineering knowledge preferred; office in Whitehall. No person resident more than 10 miles away or already on Government work will be engaged.—Address, G 654, Offices of ENGINEERING.

Junior Draughtsman Wanted

for night work by Controlled Establishment in London, S.E. Man with knowledge of jigs and tools preferred. State age, experience and salary required. No person on Government work or beyond the 10 mile radius need apply.—Address, G 629, Offices of ENGINEERING.

Required, for Important

Government Work. Junior Jig and Tool DRAUGHTSMEN, accustomed to designing Jigs and Tools for the rapid production of Automobile Parts. No person already employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 3156. G 635

TO ENGINE-DRIVERS, STOKERS, FIREMEN, AND OTHERS.

Wanted, Early in May, at

the Convalescent Home, Hunstanton, Norfolk, a Steady MAN, of good character, accustomed to Institution work, to drive a small laundry engine, attend to hot-water boilers, &c., and heating apparatus, and fill up his time by general help in laundry; and otherwise as required. Wages £3 per month. The Home is open for patients from March 1st to December 24th, yearly. —Apply, not later than May 5th, by letter, stating age, previous experience and references, to HON. SECRETARY, Convalescent Home, Hunstanton. G 648

Wanted, Competent Gravel

PIT MANAGER and SALESMAN. Ineligible.—Send references and particulars with salary required, by letter only, to HALL & CO., CROYDON, LTD., Victoria Wharf, Croydon. G 642

Energetic Router for Aero-

plane Works near London. Preferably man with shop and aviation experience. No person resident more than 10 miles away or already on Government work need apply. State age, salary and qualifications. — Write, BOX 559, SAMSON CLARK'S, 56, Great Portland Street, W. 1. G 616

A Large Firm of Engineers,

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4329, Offices of ENGINEERING.

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A.M.I.M.E., 16 years' manufacturing experience, specialist on design of electrical machinery, instruments and protective gear, also petrol engines, OPEN for APPOINTMENT shortly as Technical Supervisor, Designer or similar capacity. Could introduce valuable patent in connection with aero-electrical apparatus. Salary about £300.—Address, G 529, Offices of ENGINEERING.

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Engineer (48); construction of works, industrial buildings, re-inforced concrete, steel-work, sewerage, roads, bridges; workshop experience, SEEKS POSITION in works or office.—Address, G 470, Offices of ENGINEERING.

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DESIRES ENGAGEMENT as Superintendent, Clerk of Works, or Quantity Surveyor. Experienced building, bridge, reinforced concrete and steelwork erections. Excellent testimonials.—Address, G 640, Offices of ENGINEERING.

Mechanical Engineer (30),

Ineligible, REQUIRES responsible POSITION; Public School education, thorough practical and theoretical training in general engineering, extensive experience in erection, maintenance and testing of fully-equipped steam-raising plants; used to control of men; disengaged.—Address, G 650, Offices of ENGINEERING.

To Engineers and Manufac-

turers not builders of Marine Engines who desire to respond to the invitation of the Shipping Controller.—Advertiser (45), with wide experience marine and manufacturing, many years in administrative posts, OFFERS SERVICES. Highest qualifications. Replies will be regarded as strictly confidential.—Address, G 653, Offices of ENGINEERING.

Russia.—Commercial En-

GINEER, with mechanical and electrical training, lately returned from a business tour in Russia, WISHES to NEGOTIATE with a responsible Financial and Merchant House, or Manufacturing Concern desiring to open up or extend their existing business relations with Russia, with a view to acting as their Sole Representative in that Country. Advertiser is an Englishman, 42 years of age, speaking several languages. Thorough knowledge of Continental trade customs, having lived several years abroad.—Please address communications, G 588, Offices of ENGINEERING.

Capable Young Engineer, 11

years' fitting, machine and inspection practice and control, DESIRES CHANGE. Now engaged as foreman over large aeroplane shop. Commercial output a certainty.—G 607, Offices of ENGINEERING.

Situation Wanted, London

district, to manage department or small works. Expert turret and repetition work; well up small engineering, tool design and making, munitions.—FAIRVIEW, Rusham Park Avenue, Egham. G 567

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Good Draughtsman and Mathematician, 10 years shop control and D.O. experience on high class rep. work, seeks suitable position with firm on war work.—Address, G 637, Offices of ENGINEERING.

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methods. Good results guaranteed. Address—
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DESIGN OF FLAT ARCHES WITH FIXED ENDS.

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THE designing of fixed arches loaded by dead and live loads is generally considered difficult and lengthy, owing to the fact that they are trebly statically indeterminate, and that consequently their stresses can only be found by applying the elaborate calculations involved in the elastic theory. The greatest difficulty occurs in the case of very flat arches, where the effect of the shortening of the arch ring under the action of the thrust must be taken in account if sufficient accuracy is to be obtained. As practically all arches, whether for bridges, floors, foundations, retaining walls, &c., are very flat, it goes without saying that every simplification that can be introduced into the corresponding calculations is bound to be very useful. The present article is intended to explain a new method for finding, in a very few minutes, the maximum stresses in flat arches, under dead and live loads.

The writer does not claim that his method will give practical accuracy in every possible case; no simplified method can ever claim such an advantage, nor be intended to make the more general methods superfluous. The new method explained below will only apply to arches having practically a constant section throughout their length. This case is very general in practice, and even where the arch ring is generally made stronger at the haunches than at the crown, as in bridgework, the method may be very useful for estimating and similar purposes.

Although the new method has been deduced from theory for the case of parabolic arches, it will be shown that a high degree of accuracy is obtained if applied to non-parabolic ones. This is not surprising when it is remembered that only flat arches are considered.

Before describing the actual method it may be useful to point out that the only reliable method of dealing with live loads in arch design is to make use of influence lines. As the reader may not be quite familiar with this subject, the writer would refer to an article published some three years ago by Mr. R. N. Stroyer, in ENGINEERING (see vol. XCV, No. 2,469, of April 25, 1913, page 555).

The simplest definition of an influence line—which always applies to a special cross-section of the arch—is: A curve showing, by the variation of its ordinates, how a unit force moving over the arch affects the special section to which the line applies. Thus the influence line for the bending moment at the crown shows how this B.M. varies when a unit force moves over the arch; if the unit force acts on the arch at a certain point, the corresponding crown B.M. is given, to a certain scale, by the corresponding ordinate m_c of the influence line; if a point load P acts at the same point, the crown B.M. will be $P \times m_c$; if a uniformly distributed load p_1 per unit length wholly or partly covers the arch, the crown B.M. will be measured by the corresponding total or partial area of the influence line, multiplied by p_1. All this is made quite clear in the above-mentioned article, to which the writer would refer those wishing for more details on this subject. In this article the writer will confine himself, in dealing with moving loads, to giving a quick and accurate method of finding the necessary influence lines.

I. PRACTICAL USE OF NEW METHOD.

Let m_0 be the ordinate of the influence line for the left haunch B.M., it being well understood that m_0 has a special value at every point of the arch line; p_0, q_0 and m_c respectively the ordinates of the influence lines for the vertical and horizontal reactions at the left haunch and for the crown B.M.; $a = R \div L$, the ratio of the rise R to the span L; $b = r^2 \div L^2$, the square of the ratio of the radius of gyration r of the cross-section, to the span L; x the abscissa of any point of the arch line with

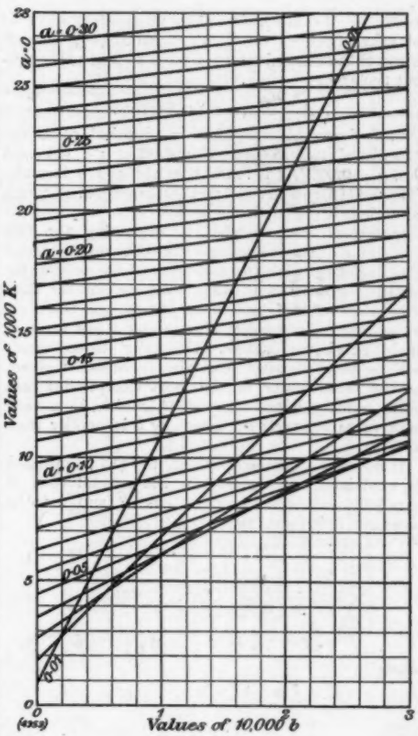


FIG. 1.

the value of 10,000 b is set out as abscissa, and 1,000 K is then obtained as ordinate at this point to the graph line corresponding to the a in question.

Referring, then, to Table I, it will be seen that it is divided in 13 columns and 12 lines. As shown by the values of $x \div L$ given in the first line, each of the columns 3 to 13 corresponds to a special point of the arch line, the column 3 corresponding to the crown and 13 to the right haunch if $x > 0$ and to the left haunch if $x < 0$.

The ordinates of the influence line for the vertical reaction at the left haunch are readily given by the figures in the lines marked II and III; they are the same in all cases.

Having found the value of the coefficient K by Fig. 1, line IV can be filled in, giving the ordinates of the influence line for the horizontal thrust; this line is symmetrical about the crown.

If these values of q_0 are multiplied by $2a \div 3$, the results being written in line V, and if, further, the figures in line VI are subtracted from the former, the differences are the values of $m_0 \div L$ for $x > 0$; they are written in line VII.

To obtain the values of $m_0 \div L$ for $x < 0$ (line IX) the figures in line VIII are subtracted from those in line VII.

Finally, if the values of q_0, as in line IV are multiplied by $a \div 3$, and these products, in line XI, are subtracted from the figures in line X, the differences (line XII) are the values of $m_c \div L$; the corresponding influence line is symmetrical about the crown.

All these operations take less time to carry out than to describe, and they are all that is required to enable the influence lines to be drawn for the haunches and for the crown, having obtained 20 equidistant ordinates. If for the purpose of rough estimates 10 points are deemed sufficient for every influence line, it is only necessary to fill in every other column of Table I; this does not affect the result, as all the columns are absolutely independent of one another.

The following will be of great help to draw the influence lines with greater accuracy.*

The tangent to p_0 is parallel to the reference line both at $x = +L \div 2$ and $x = -L \div 2$; the p_0 line has an inflexion point at $x = 0$.

The q_0 line is tangential to the reference line at $x = \pm L \div 2$ and has a maximum at $x = 0$.

The m_0 line is tangential to the reference line at $x = +L \div 2$; at $x = -L \div 2$ this curve makes an angle with the reference line, the tangent of which is 1 (the co-ordinates being $x \div L$ and $m_0 \div L$).

The m_c line is tangential to the reference line at $x = \pm L \div 2$; at $x = 0$ this curve has a point where the two symmetrical branches meet; each of these branches forms an angle with a parallel to the reference line the tangent of which is $1 \div 2$ (the co-ordinates being $x \div L$ and $m_c \div L$).

TABLE I.

I	$x \div L$	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.5
II	p_0 ($x > 0$)	0.5	0.4252	0.3520	0.2817	0.2160	0.1562	0.1040	0.0607	0.0280	0.0072	0
III	p_0 ($x < 0$)	0.5	0.5748	0.6480	0.7183	0.7840	0.8438	0.8960	0.9393	0.9720	0.9928	1
IV	q_0 ... ... =	0.02083 K	0.02042 K	0.01920 K	0.01725 K	0.01470 K	0.01172 K	0.00853 K	0.00542 K	0.00270 K	0.00075 K	
V	$\frac{2}{3} a q_0$	—	—	—	—	—	—	—	—	—	—	0
VI	—	0.1250	0.1114	0.0960	0.0796	0.0630	0.0469	0.0320	0.0191	0.0090	0.0024	0
VII	VI–VI = $m_0 \div L$ ($x > 0$) ...	—	—	—	—	—	—	—	—	—	—	0
VIII	—	0	0.0248	0.0480	0.0683	0.0840	0.0938	0.0960	0.0893	0.0720	0.0428	0
IX	VII–VIII = $m_0 \div L$ ($x < 0$)	—	—	—	—	—	—	—	—	—	—	0
X	—	0.1250	0.1013	0.0800	0.0613	0.0450	0.0313	0.0200	0.0113	0.0060	0.0013	0
XI	$\frac{1}{3} a q_0$	—	—	—	—	—	—	—	—	—	—	0
XII	X–XI = $m_c \div L$	—	—	—	—	—	—	—	—	—	—	0

A. PARABOLIC ARCHES.

1. *Influence Lines.*—The given quantities are generally the span L, the rise R, and the cross-section or its radius of gyration r; this gives $a = R \div L$ and $b = r^2 \div L^2$. The influence lines are then found in the following way:—

Referring to Fig. 1 it will be seen that its co-ordinates are 10,000 b and 1,000 K, K being a certain coefficient, the value of which is found as ordinate. The graph itself is composed of a series of straight lines, each of which corresponds to a certain value of $a = R \div L$. To find K regard to its centre line, the values of x being positive to the right and negative to the left.

2. *Effect of Uniformly Distributed Load p_1.*—Let M_0, P_0, Q_0 and M_c be respectively the left haunch B.M., the vertical and horizontal reactions at the left haunch and the crown B.M. under a uniformly distributed load p_1 per unit length, covering the whole arch. These values are given by the following equations:—

$$\frac{Q_0}{p_1 L} = \frac{1}{90\,K} + \frac{1.6\,b\,K^1}{K} \quad . \quad . \quad . \quad (1)$$

$$\frac{M_0}{p_1 L^2} = \frac{2}{3}\,a\,\frac{Q_0}{p_1 L} - \frac{1}{12} \quad . \quad . \quad . \quad (2)$$

$$M_c = -\frac{1}{2} M_0 \quad . \quad . \quad . \quad . \quad (3)$$

$$\frac{P_0}{p_1 L} = \frac{1}{2} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where

$$K^1 = 0.71\,(1 - a) \text{ for } 0.1 < a < 0.3$$

and

$$K^1 = \frac{2}{3} - 0.27\,a \text{ for } 0 < a < 0.1$$

3. *Effect of Change of Temperature.*—If δ denotes the coefficient of expansion, the effect of an increase of temperature of t^0 is given by the following formulæ:—

* These remarks do not only apply to parabolic arches, but to all symmetrical arches with fixed ends. They are immediate consequences of Maxwell's theorem.

The thrust is equal to

$$Q_t = \frac{E\,\delta t\,\Omega\,b}{a\,K} \quad . \quad . \quad . \quad . \quad (5)$$

where Ω is the area of the cross-section.

The haunch bending moment is

$$\frac{2}{3} Q_t\,R \quad . \quad . \quad . \quad . \quad (6)$$

and the crown bending moment

$$-\frac{1}{3} Q_t\,R \quad . \quad . \quad . \quad . \quad (7)$$

B. NON-PARABOLIC ARCHES.

1. *Influence Lines.*—The above method, theoretically accurate for parabolic arches, may be applied to non-parabolic ones, and will give the following degree of approximation :—

For $0 < a < 0.15$ the error in m_0 and m_c will be smaller than about 5 per cent. of their respective maximum values, the error in q_0 being smaller than 1 per cent. of its maximum value ; p_0 will be given accurately.

For $0.15 < a < 0.20$ the error in m_0 and m_c will be smaller than about 10 per cent. of their respective maximum values, the error in q_0 being smaller than about 1½ per cent. of its maximum value ; p_0 will be given accurately.

The above approximations apply to all arches between the parabola and the circle of a given span and rise.

2. *Effect of Uniformly Distributed Load p_1.*—It is not advisable to use the above formulæ (1), (2), (3) and (4) in the case of non-parabolic arches, as the error made is too considerable.

3. *Effect of Change of Temperature.*—This effect may be calculated by the formulæ (5), (6) and (7) given for parabolic arches, the approximation obtained being about the same as in the calculations for influence lines.

II. THEORETICAL PROOF.

The full theoretical proof of the above method would be rather lengthy, and the writer will consequently confine himself to giving a general idea only of the principle of the method used.

Let M, H and S be respectively the bending moment, the thrust and the shear force at any point of the arch loaded by one unit vertical force acting at the point of abscissa x; under this loading the reactions at the left haunch will be p_0, q_0 and m_0 (ordinates of influence lines at point x) ; m, h and s the corresponding values to M, H and S in the same arch made statically determinate by considering it as cantilevered out from the right haunch and completely free at the left; I and Ω the moment of inertia and the area of the cross-section at any point of the arch line ; y the ordinates of the arch line above the horizontal line through the haunches; ds the element of arch line ; ρ the height of the elastic centre given by

$$\rho = \frac{\int \frac{y}{I} ds}{\int \frac{1}{I} ds}$$

the integrals being taken throughout the arch line ; z the ordinates of the arch line with reference to an horizontal line through the elastic centre, so that

$$z = \rho - y$$

The work done in bending, compression and shear is then

$$W = \frac{1}{2E}\int \frac{M^2}{I} ds + \frac{1}{2E}\int \frac{H^2}{\Omega} ds + \frac{1}{2G}\int \frac{S^2}{\Omega} ds \quad . \quad . \quad (8)$$

in which the integrals are taken throughout the arch line and

$$\left.\begin{aligned} M &= m - q_0\,y + p_0\left(\frac{L}{2} + x\right) + m_0 \\ H &= h + p_0 \sin a - q_0 \cos a \\ S &= s - p_0 \cos a - q_0 \sin a \end{aligned}\right\} \quad . \quad (9)$$

According to the principle of minimum work

$$\frac{dW}{dm_0} = 0 \qquad \frac{dW}{dp_0} = 0 \qquad \frac{dW}{dq_0} = 0 \quad . \quad (10)$$

Developing equations (10) by taking in account (8) and (9) it is found that

$$p_0 = \frac{\int \frac{x^2}{I} ds - x\int \frac{x}{I} ds + \int \frac{\sin^2 a}{\Omega} ds + \frac{E}{G}\int \frac{\cos^2 a}{\Omega} ds}{\int \frac{x^2}{I} ds + \int \frac{\sin^2 a}{\Omega} ds + \frac{E}{G}\int \frac{\cos^2 a}{\Omega} ds} \quad (11)$$

$$q_0 = \frac{\int \frac{z\,x}{I} ds - x\int \frac{z}{I} ds + \left(\frac{E}{G} - 1\right)\int \frac{\sin a \cos a}{\Omega} ds}{\int \frac{z^2}{I} ds + \int \frac{\cos^2 a}{\Omega} ds + \frac{E}{G}\int \frac{\sin^2 a}{\Omega} ds} \quad (12)$$

$$m_0 = \rho q_0 - \frac{L}{2} p_0 + \frac{\int \frac{x}{I} ds - x\int \frac{1}{I} ds}{\int \frac{1}{I} ds} \quad . \quad . \quad (13)$$

where all the integrals of the numerators have to be taken between the limits x and $L \div 2$, whereas those of the denominators have to be taken throughout the arch.

A. PARABOLIC ARCHES.

1. *Influence Lines.*—If only practical cases are considered, where generally $0.02 < a < 0.3$ and $0 < b < 0.0003$, it is found that the above formulæ (11) and (12) can be considerably simplified, although retaining, if not their theoretical accuracy, at least a practical one. Indeed, in neglecting the two last terms of the denominator and the numerator of (11), together with the last term of the numerator of (12), the error in p_0 and q_0 is always smaller than 2 per cent. of their maximum values, and the error in m_0 and m_c is smaller than about 5 per cent. of their maximum values. Generally these errors will be *much* smaller than the percentages given, as the latter occur in the most exceptional case only, namely when $b = 0.0003$, which is a very high value in practice ; generally b is smaller than 0.0001.

If now the formulæ (11), (12) and (13), simplified as explained, are applied in the special case of parabolic arches, assuming I cos a* and Ω to be constant, it is found that

$$p_0 = 2\left(\frac{x}{L}\right)^3 - \frac{3}{2}\frac{x}{L} + \frac{1}{2} \quad . \quad . \quad (14)$$

$$q_0 = \frac{1}{K}\left[\frac{1}{48} - \frac{1}{6}\left(\frac{x}{L}\right)^2 + \frac{1}{3}\left(\frac{x}{L}\right)^4\right] \quad . \quad (15)$$

$$\frac{m_0}{L} = \frac{2}{3} a\,q_0 - \frac{1}{2} p_0 + \frac{1}{8} + \frac{1}{2}\left(\frac{x}{L}\right)^2 - \frac{1}{2}\frac{x}{L} \quad . \quad (16)$$

where

$$K = \frac{4}{45} a + b\left[\frac{E}{2\,G\,a}\sqrt{1 + 16\,a^2} - \frac{E - 2\,G}{8\,G\,a^2} l_e\left(4\,a + \sqrt{1 + 16\,a^2}\right)\right] \quad . \quad (17)$$

This is the value given by Fig. 1. Table I is nothing else but the application of equations (14) to (16).

2. *Effect of Uniformly Distributed Load p_1.*—To find this effect the equations (11) to (13) have to be taken, with all their terms, as otherwise the error made is too considerable.

It is obvious that the influence of a uniform load p_1 is found by integrating the influence lines. This is the origin of formulæ (1) to (4) where

$$K^1 = \frac{1}{16\,a^2}\sqrt{1 + 16\,a^2} - \frac{1}{64\,a^3} l_e\left(4\,a + \sqrt{1 + 16\,a^2}\right) \quad (18)$$

This complicated value of K^1 is practically identical with the simplified one given in the first part of the present article.

3. *Effect of Change of Temperature.*—If a change of temperature be considered, equations (10) have to be written according to Castigliano's theorem

$$\frac{dW}{dm_0} = 0 \qquad \frac{dW}{dp_0} = 0 \qquad \frac{dW}{dq_0} = \delta t L$$

The developing of these equations gives formulæ (5) to (7).

B. NON-PARABOLIC ARCHES.

The writer has studied circular arches in the same way as shown above for parabolic arches, and the results obtained fully justify the remarks on the practical accuracy of the "A" method applied to "B."

NOTES.—I. It may be interesting to point out how Fig. 1 shows to what extent the work done in compression and shear affects the thrust.

If the work done in bending only be considered, as is often done with a view to simplification, the coefficient K becomes (make $b = 0$)

$$K = \frac{4}{45} a$$

so that all the lines of the graph become parallel to the b axis and cross the K axis at the same point as originally. Consequently the effect of the work done by H and S is to impart a certain slope to the graph lines, the angle increasing from 0 to 90 deg. as a decreases from an infinitely great value to zero. If $a = 0$ the arch becomes a straight beam fixed at both ends.

II. It is generally believed that no bending moments occur in an arch the centre line of which follows the stress line under permanent loads. This is wrong, and, generally speaking, it is impossible to make an arch in which no bending moments occur under permanent loads. If, for instance, a uniformly distributed load be considered, the stress line is a parabola ; but, notwithstanding this, a parabolic arch uniformly loaded has bending moments, which may be considerable if the arch is very flat. This is due to the shortening of the arch under the action of the thrust, which is too often neglected with a view to simplification, although it can be taken in account practically without supplementary calculations.

III. The principle of minimum work as applied in the present article is not "a somewhat metaphysical argument on which it is necessary to rely in absence of the elastic theory."* On the contrary, it is part of the elastic theory. The principle used by some writers is an older one, to which a new and purely scientific expression has been given in recent years.† It is under this more scientific shape that it has been used above.

* For flat arches this means practically a constant section throughout, although theoretically it means a very slight increase between crown and abutments—about 2 per cent. for $a = 0.1$.

* See Ernest H. Sprague, on "Stability of Arches," 1916.

† See, for instance, A. Merton, "Travail de déformation des solides élastiques" (*Annales des Ingénieurs sortis de Gand*).

A NEW VICKERS MACHINE GUN SHOP.

WE are permitted to publish in this issue, on pages 393, 394, and 395, and on Plates XXXVI to XXXIX, a series of drawings and perspective views illustrating one of the new Vickers machine gun shops which have had to be erected, equipped, and started up with great rapidity in order to meet the demands of our forces at the Front. The idea in publication is to demonstrate the ready response of our manufacturers to meet capital commitments, the energy displayed on all hands to ensure rapidity of construction and subsequent supply of munitions, and the skill and resource to attain not only the fullest output from a given floor area, but the highest efficiency measured from the standpoint of manpower available. In this particular factory there are admirable proofs of all of these. We have here a building with a floor area of nearly 2½ acres, a cubical content of 2,000,000 ft., and accommodating over 1,000 machines of specialised type, driven by electric power transmitted through the medium of 6,000 ft. of line shafting and 40,000 ft. of machine belting ; and yet actual manufacturing work was commenced within three calendar months of the date when the ground—a potato field—was first taken possession of, while in two months more the whole establishment was in complete working order and a steady supply of machine guns was being despatched to the Front. More satisfactory still, the whole of the machining work in the manufacture of these machine guns—one of the most intricate units of mechanical production—is carried out by women workers.

The rapidity with which this thoroughly substantial building was built is due in part to the suitability of the design and in part to the organising capability of the Vickers staff and the contractors—for the constructional steelwork Messrs. Dorman, Long and Co., of Middlesbrough, and for the builders' work, Messrs. G. H. Gunning and Sons. The co-operation of the Ministry of Munitions was an important factor to the same end. The design was prepared by the Vickers staff with due regard to facilities available for the securing

of material. Only in small details was it found necessary to modify the original design.

The main section of the building, as shown in Fig. 1, has a length of 337 ft. 6 in., while the width, as shown in Fig. 2, made up in bays of equal widths, is 75 ft.; the roof principals have a span of 25 ft., but intermediate columns are inserted to help to support the first and second floors. The end elevation, Fig. 3, shows that the outside walls are of brick with large glazed steel sashes. Fig. 3 also shows in elevation the staircase, at the extreme end of the building, marked on the plan of the ground floor, Fig. 4. Before the building had been advanced to any extent it was decided to construct an annexe, making the building L-shaped in plan, as shown in Fig. 4. This annexe has a length of 125 ft. and a width also of 75 ft. It is of similar construction to the main building. The ground had originally a natural slope, and instead of making the ground floor of the building at the same level throughout, thereby involving extensive excavation, it was decided to vary the level of this floor by introducing two steps, each of 4 ft., as shown in the longitudinal elevation, Fig. 1. The three levels of the floor thus formed communicate with one another by alley-ways 5 ft. 6 in. wide, having slopes of 1 in 5. One section—that to the right of Fig. 1—is 67 ft. high from the ground to the apex of the roof, the central part is 71 ft., while that to the left of Fig. 1, as well as 50 ft. of the annexe, is 75 ft., the remainder of the latter being 71 ft. Figs. 5 and 6, on page 394, illustrate the progress in the construction of the building; work was commenced on July 30, and as the date when each photograph was taken is given, these views, and others given on Plate XXXIX, speak eloquently of the rapidity with which the work was executed.

For the thorough appreciation of this remarkable progress a study of the details to prove the substantial character of the building is necessary. A typical column, with its brackets, and a typical roof principal, are shown in detail on Plate XXXVI. Figs. 9 to 13 are details of the lower part, and Figs. 14 to 16 details of the upper part of a column in that part of the building to the right of Fig. 1, that is, of the least height. It may be said that in the building there are 266 of these columns. As all brackets and details are shown, a description is unnecessary. This applies also to the details of the roof principals shown on Figs. 17 to 25 on the same plate. The roof covering, it may be stated, is of inch boarding nailed to wooden purlins and covered with fibro-cement slates. Heywood's continuous glazing is introduced on the north side of each of the three bays of the roof, and the arrangement of the swinging ventilators, which is shown on the general cross-section, Fig. 26 on Plate XXXVII, is interesting.

As already indicated, there are two main staircases, one at the extreme end of the main building and the other in the angle formed by the main building and the annexe, as shown in the plan, Fig. 4. These staircases are of substantial construction and, in view of the suitability of the design and the extensive need for such exits, we reproduce on Plate XXXVIII full drawings of the staircase in the angle formed by the annexe and the main building. Fig. 32 is an elevation from the inside of the main building, and Fig. 33 one from the annexe, while a sectional elevation is given in Fig. 34. The details published in Figs. 32 to 39 so completely show the scantlings that it is unnecessary here to give a further description.

The contract was signed on July 19. Within a week of this a large quantity of material had already been specially rolled. The first steelwork was delivered on the site on August 10, and the first column was erected on August 12. Special consideration had been given to the unloading, hoisting, and fixing in position of all material with the minimum of handling in order to ensure rapid progress. Two 5-ton Scotch derrick cranes, one of which is seen in Fig. 5, on page 394, were employed. The jibs were of 75-ft. range, and the cranes were mounted on bogies running on two parallel tracks, so placed that the full cross-section of the building could be spanned by each jib. A special supply siding had been laid in close proximity to the site of the building, so that the cranes could be used for lifting sections of the columns from the railway trucks, the material being sent forward from the works at Middlesbrough with the trucks labelled according to the particular crane by which the contents were to be handled. This provision proved a useful assistance towards rapidity of work by obviating confusion. The cranes were placed in a position facing each other at the centre of the main building and were moved outwards towards the end of the building as the work progressed. By this method the steel frame of the building, beginning at the centre, was completed from base to ridge towards each end, so that the building work, construction of walls, floors, roof covering, &c., could be proceeded with freely without hindering the continuance of the erection of the steelwork.

The whole of the steelwork for the main building, totalling 1,320 tons, was delivered and erected by September 12. Meanwhile the builders' work was being pushed sharply ahead on top of the steelwork. The millwrights' work had been so far brought forward that the first machine tool was driven round

Fig. 1. LONGITUDINAL ELEVATION OF STEEL FRAME.

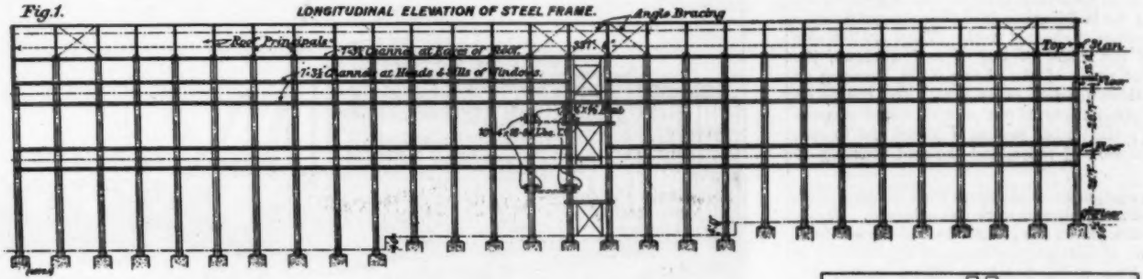
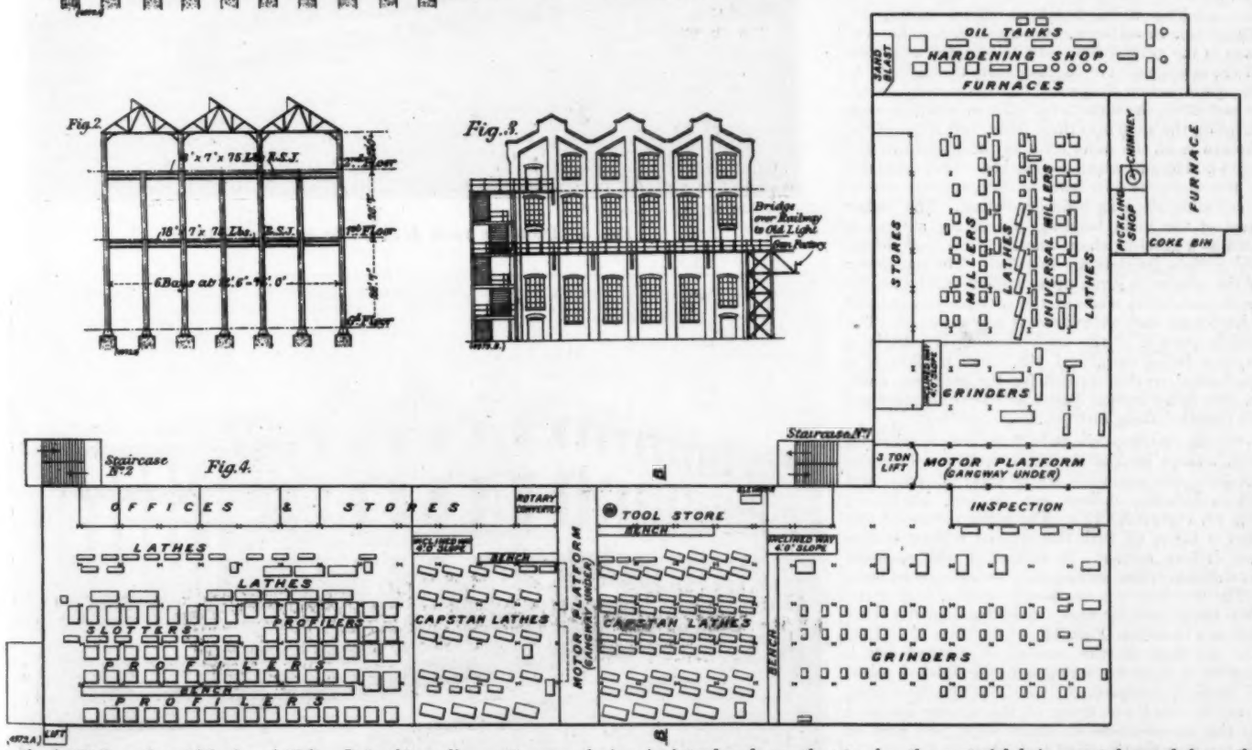


Fig. 2.

Fig. 3.

Fig. 4.



under power on October 1. On October 25 the tool room on the top floor of the building was started up as a manufacturing concern. Later we shall refer to the importance of thus giving preference to the tool room. The significant point here is that the building was designed, made and erected so that a shop was actually working within a period of three calendar months from the giving of the order. The annexe, which involved the use of 380 tons of structural steel, was proceeded with immediately following the completion of the main building and with the use of one of the cranes the steelwork was erected by October 23, and before the end of the year the whole of the building was in actual operation constructing guns.

Some idea of the extent of the operations carried out in a little more than three months is given by the fact that the building involved the rolling of 6½ miles of one section of channel steel. There are 248 side windows and 1,350 ft. run of roof windows, the number of panes of glass being 9,500, covering an area of three-quarters of an acre. The boards on the two upper floors, if put on end, would measure 21 miles; the timber purlins, if placed end to end, would measure 2¾ miles, and the roof boarding 15 miles.

In the equipment of the shops with machine tools, &c., equally expeditious work was achieved. Fig. 4, on page 393, shows the ground floor of the building, and serves to indicate the compact arrangement of the machine tools, benches, offices, stores, &c. There are, in addition, two upper floors, but the plan of the ground floor may be accepted as typical of the arrangement of the machinery throughout. In the main portion the ground floor, as already stated, is not all on the same level. There are two steps dividing the shop into three parts, and 50 ft. of the annexe is at the same level as the portion of the main building to which it connects. The remainder of the annexe is 4 ft. lower in level, and has a communicating slope as before described. The higher level of the main building and of the annexe is used as a grinding shop, where vertical, cylindrical, and surface grinders are installed. The remainder of the annexe is given up to millers and lathes for small tool work, while at the extreme end is built a hardening shop with furnaces and oil tanks. The middle portion of the main building is entirely a capstan lathe shop, and the third portion is a mechanics' section, except for the profiling work. In this latter section lathes and slotting machines are installed along with profiling machines.

On the first floor about half the area is taken up with a large horizontal milling section. Generally speaking, the machines are grouped in types, and 120 automatic millers are in one block (see Fig. 43, Plate XXXIX). The other portion of this floor is taken up with the vertical milling section and drilling section. A number of odd machines for drifting, spline milling, &c., are also placed here.

The top floor is a mechanics' section, half of the shop being used for final assembling, and the other half as a tool shop (Figs. 41 and 42, Plate XXXIX). The top floor of the annexe is divided into a number of areas for accommodating finished parts, an inspection department, sand-blasting, browning, &c. The two lower floors of the annexe are used for the manufacture of small tools, and part of the top floor for the small tools store.

The factory is entirely electrically driven, the system being that of using an overhead central platform for taking the motors, which was introduced some ten years ago by this section of the Vickers factories. In this instance the system has been pushed a step further: high-tension current is brought into the building at 3,000 volts from the company's power station on the river bank, which is some distance away, and converted by means of Vickers rotary converters, which are placed at one end of the platform on the ground floor, into 210-volt direct current. The controlling switchboard is placed on the motor platform of the ground floor, and direct-current conductors are led direct from the switchboard to the motors on the platform, thus reducing the direct-current wiring to a minimum. This system has the advantage of having the whole of the motors driving the line shafting centralised and under easy observation of the attendant. The electric motors are by the Electric and Ordnance Accessories Company—a subsidiary company of Vickers, Limited—and are placed on each side of the motor platforms; they drive by belts and pulleys, as indicated on the cross-section (Fig. 26 on Plate XXXVII), direct to the line shafting.

The line shafting runs in "Cooper" roller bearings supported on brackets riveted to the main columns of the building. Countershaft girders, as shown in Fig. 26 on Plate XXXVII, are arranged midway between the machine drive and the main shaft, and the countershafts are supported by special brackets secured to the countershaft girders by hook bolts, shown in Figs. 29 to 30 on the same plate. All the fittings in connection with rigging up the countershafts are standardised, and any countershaft with the hangers supplied by the machine tool makers can be fitted up without the millwright having to drill a single hole, the arrangements being as indicated on the details. Figs. 7 and 8 on page 395 show the arrangement of the striking gear. It will be noticed that the cast-iron knee bracket is moulded to suit the section of the 9 in. by 4 in. countershaft girder, and is secured to it by means of hook bolts, two at the top and one at the bottom. The brackets are cast in two widths, the broader pattern being for the heavier countershafts. As practically all the machine tool makers now supply countershafts with hanger bearings as their standard, it will be seen that by this method of erection all designs can easily be fitted up without any serious trouble to the millwright. The more usual countershaft is shown in Fig. 8, but if the striking lever cannot be arranged to come in the required position by this arrangement the design shown in Fig. 7 is used. The small castings which support the fulcrum of the striking lever are not machined in any way, and are kept in stock by the hundred. The striking lever is made of wood, and the bolt holes are protected by steel plates screwed on the face of the lever.

The machine tools are of the lighter, accurate variety, and nearly every well-known machine tool maker, producing the type of machinery required, of England and America, is represented, careful consideration having been given to get machines best adapted to the work. In laying out the shop, however, the greatest number of machines of one type have been purchased in order to reduce spare parts.

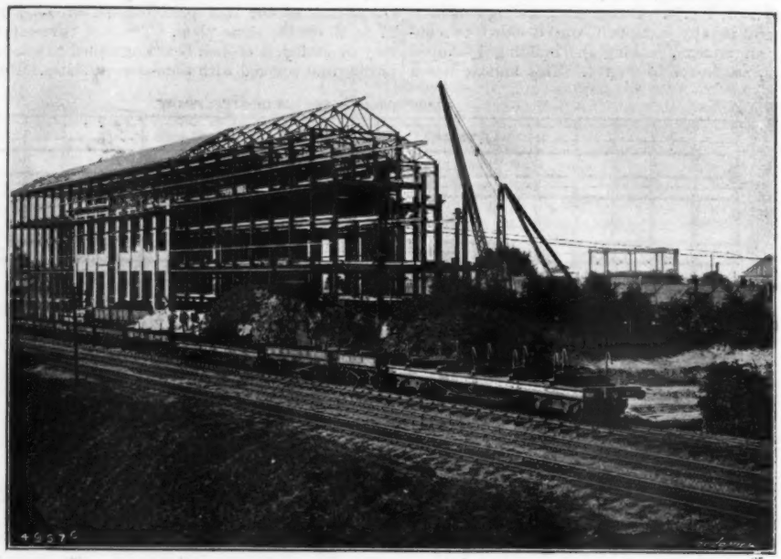


FIG. 5. PROGRESS FROM JULY 19 TO SEPTEMBER 10.

FIG. 6. PROGRESS TO OCTOBER 22.

The building is heated throughout by unit steam heaters with electrically driven fans. The top of each unit is connected by means of ducts with the outside atmosphere, so that the shop floor can be flooded with cool air in summer, or by circulated warm air in winter.

On Plate XXXIX there are reproduced four perspective views of the complete factory, one, Fig. 40, being an external view showing the main building and the annexe, while the other three are interior views showing the top and middle floors. Fig. 41 is a view on the top floor of the main building, and shows the state of the tool room as it was started up on October 30. It will be noticed that although the shop was not complete quite a number of men had been got to work. Fig. 42 is a view taken from the same position on December 31. By this time the fitting department beyond the tool shop was in full swing, and a bench of fitted gun casings had been brought into the foreground. Fig. 43 shows the automatic milling section on the middle floor. On the milling machine in the foreground can be seen the type of cutter and fixing produced in the tool room shown in the preceding engravings. It should also be noted that there is not an operator to each machine, one woman supervising the working of several machines. On this floor there are 120 machines in one block of the type shown in the foreground.

Equally interesting was the provision made for getting the shop under way as soon as the tools could be installed. This required great foresight, because female labour was to be used to the maximum extent. As a consequence considerable modification in the designs of jigs and fixings had to be made, with the object of simplifying the machining operations. Again, as it was impossible to obtain tool designers and tool makers, a number of the better-educated apprentices at the works were drafted on to the re-designing of the methods of manufacture. A section of the old machine gun department was therefore allocated to the manufacture of the jigs and fixings thus designed for the new shop where female labour was to be employed. Where possible the assistance of tool-making firms was also obtained in order to duplicate gauges and receivers to meet the additional inspection requirements for the testing of interchangeability of the gun component parts. Thus, as soon as part of the building was roofed in the top floor was taken possession of in order to instal the suitable machinery available for use exclusively on tool-making.

To begin with it was decided to concentrate machine work in the new shop on the controlling details of the gun, leaving other details to be provided by the old shops, while at the same time work was continued to complete the whole range of tools, jigs, gauges, receivers, &c. As the new building developed the manufacture of the remaining units of the gun was added to the original machine operations in the new shop, the whole of the machining in this new factory being carried out by women labour. This arrangement achieved a regular growing output without overlap and a minimum expenditure on gauges, receivers and tools, and conduced also to specialising in the output of certain details in each department, with a consequent rapid production and economy in machine setting.

It is not permissible to indicate the volume of output, but from what we have written it will be accepted that this new factory—one of many which have been erected since the beginning of the war—once more establishes the enterprise, energy and resource of British engineering. The building is a thoroughly substantial one, and will stand long after the war is over. The machine tools within it are of highly specialised design to undertake specific operations with the exercise of the least measure of intelligence on the part of the operator. There is ensured economy in man-power, extreme accuracy —to one-thousandth part of an inch—and absolute interchangeability. Whether, when the war is over, these tools can be utilised with the same degree of efficiency for peace productions remains to be seen; but it would be a striking reversal of the policy which has enabled such highly efficient factories to be equipped for war work if, in peace time, the same machine tools, if used for unsuitable work, failed because unsuited in design to achieve corresponding efficiency. However suitable a building, the machine tools used in future for engineering productions must, in practically all cases, be of highly specialised design. This result must be attained even at the cost of discarding otherwise suitable appliances. There can be labour substitution, but not indiscriminate utilisation of any type of machine tool for special machining operations.

Fig 7.

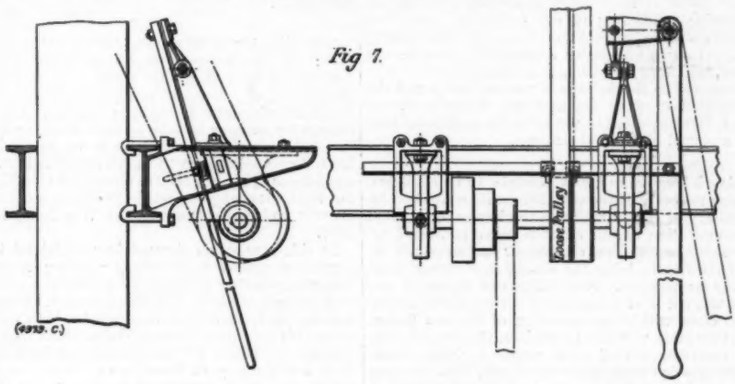
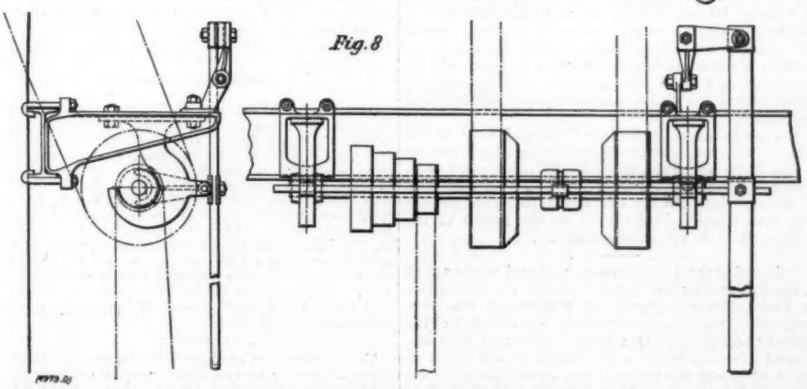


Fig. 8



THE SOCIETY OF GLASS TECHNOLOGY.

A WELL-ATTENDED meeting of the above society was held in the University, Sheffield, on Wednesday, April 18, at 2 p.m., to discuss the question of "Machinery and Labour-Saving Devices in the Glass Factory." Mr. Frank Wood, B.Sc., took the chair, and the discussion was opened by Mr. A. M. Rowland, chief technical assistant, Machine Tool Department, Ministry of Munitions.

In his preliminary remarks Mr. Rowland emphasised the need for well-planned works, because most glass factories, owing to the fact that they had been built on the patchwork system, were badly laid out. Spaciousness was very necessary, both from the point of view of overlooking of workmen and for visibility. Everything should be available and not hidden, visibility being a point conducive to good workmanship. A works, too should be accessible, both for its workpeople and for the reception and dispatch of materials. Great attention should be paid to lighting, and arrangements should be made for gradation of light, if necessary. One often found, for example, that a store room (where visibility is so essential) was quite dark. For glass cutting and polishing a room with a northern aspect was to be advocated.

In every works a study should be made of the best means of transport, particularly in regard to the reception of raw materials, the transport of materials inside the works, and the delivery of the finished articles. Overhead runways and not rails were to be advocated for a glasshouse, with a series of standardised trucks, whilst the raw material should be transported to the store by means of a bucket conveyer.

Conveying bands, too, could be employed inside the shops for the transport of glass articles to the lehr, and when cold to the sorting-room. Motor lorries should be used for delivery of finished goods, as they avoid many handlings of cases, a point of great importance in the glass trade. If glass manufacturers could evolve a lorry of the particular type needed, the motor car manufacturer would do the rest, and would produce a vehicle expressly designed to meet the special requirements of these very fragile manufactures.

Returning to the works, much labour can be saved by proper batch handling. Grading, mixing, grindng and weighing all require proper arrangement, so that as little manual labour as possible is necessary. Expense and labour, too, can be saved in the utilisation of waste heat. Commenting next upon particular glass processes, the speaker drew attention to the forward strides that were being taken in the use of compressed air in glass-blowing. The introduction of the Owens machine was a triumph for automaticity. In Germany the automatic machine was worshipped, in England it was hated, yet it conferred many advantages. The manufacture of glass tubing could certainly be improved if some automatic or semi-automatic method were used. Much labour could be saved the glass manufacturer by an interchange of tools and moulds, whilst some means should be sought whereby the taper of all stoppers should be the same, so that a stopper of a particular type would fit any bottle of that particular type. In conclusion the speaker pointed out that much information regarding new and useful machinery was available at the Ministry of Munitions. Several problems had been worked out, and others were in the process of solution, and the information was at the disposal of glass manufacturers for the asking.

Mr. F. R. Dixon-Nuttall continued the discussion, confining his remarks chiefly to the labour-saving devices employed in America in connection with the Owens machine. He gave a most interesting and succinct account of the up-to-date methods used in grinding, mixing and conveying batch to the furnaces. The batch materials are stored in huge receptacles, connected to the furnace floor by hoppers. To obtain a mixed batch, ready for filling on at the furnace, a workman runs an electrically-propelled truck beneach each hopper, which automatically discharges the requisite amount of material. Cullet, which has been finely ground, can also be added from a hopper. When the truck is full it runs off to the furnace. On its way thither the batch is thoroughly mixed by a revolving mechanism inside the truck.

Mr. S. N. Jenkinson exhibited a very interesting and instructive series of lantern slides, showing various machines used in the glass trade, including machines for cutting off, remelting, puntying, grinding, slicing, etching, shaping marbles for soda-water bottles, &c. Pictures of lehrs, batch mixers, automatic boys, &c., were also shown.

A paper by Mr. G. E. Alexander, in the unavoidable absence of the author, was communicated by Dr. Turner. The paper dealt with the Owens machine, and showed how it had revolutionised the bottle industry in the United States owing to rapidity of production and reduced prices. Bottles ranging in capacity from $\frac{1}{4}$ oz. to 13 gallons could be made on this machine, in shape and finish as good as the hand-made products. Siphons, tumblers, lamp-glasses, electric bulbs, carboys, &c., were all being turned out successfully. As many as 75,000 quart bottles could be produced by one machine in a 24-hour day. Specimens of various bottles made on an Owens machine were exhibited. No human aid was needed until the bottle was delivered cold at the mouth of the lehr, two types of which were in use, one for small and one for large bottles. Both had proved a success. A description of the batch-mixing and supply arrangements in force in an American factory, following on the lines of Mr. Nuttall's paper, was also included, it being pointed out that one man could keep six to eight furnaces supplied with batch on an eight-hour shift. A long and animated discussion followed the remarks of the principal speaker.

INDUSTRIAL NOTES.

SPEAKING recently at Sheffield, on the depreciation of machinery specially installed for the manufacture of munitions of war, Mr. Douglas Vickers stated that the wear and tear of machinery under war conditions was very much greater than in peace time. Repairs had often to be deferred, and the proverbial "stitch in time that would save nine" was omitted. A most difficult task, and probably the most important one, was the question of the proportion of the cost of the special plant laid down during the war which had to be written off as part of the cost of manufacture. Mr. Douglas Vickers took as an instance that of a plant for making shells, and he took it for two reasons: first, because the case was more simple, and, secondly, because his company was less interested in shell plant in proportion to their total capital expenditure than most firms. Buildings had to be provided; presses, lathes and boring machines put down in large numbers. The buildings were relatively light, but they had to do their work well for the purpose for which they were intended, and they might find some use after the war, provided that the trade expansion of the country demanded increased accommodation; as to the presses, boring machines and a great majority of the lathes, what could be done with them? There would not be scope for the employment of 5 per cent. of such machines for peace purposes, and the profit out of any work executed on the 5 per cent. would not pay for the upkeep of the rest. Mr. Vickers held, therefore, that in such cases the only sound financial course was to write off the whole of the capital expenditure on such machines. He added that this principle was so far recognised that most of the recent big plants had been put down at the Government's expense and were only managed by the private firms, Many of the machines put down for gun and gun-machining works were in a similar position.

We have received from the Apprenticeship and Skilled Employment Association, 53, Denison House, 296, Vauxhall Bridge-road, S.W., a series of recommendations on the arranging of apprenticeships. The association recommends a maximum apprenticeship period of five years, commencing at 15 or 16 where it is possible for the boy to remain on at school; before the indentures are signed there should be a period of trial of at least one month; wages must vary according to trade and locality, and should not compare so unfavourably as they now frequently do with the wages paid to boys in unskilled trades, thus deterring poor parents, on purely financial grounds, from apprenticing their sons; premiums should not be required, but if charged, the wages should be proportionately high; a bonus should be paid at intervals for good time-keeping, behaviour and work, as an incentive to the apprentice to do his best; general and technical education at continuation classes should be arranged for and insisted on, especially in the case of apprentices who are bound at 14, and, where possible, this should be during working hours, in order that the apprentice may come fresh to the classes and get the utmost profit from them.

As will be seen, therefore, the association and Mr. H. A. Bennie Gray, whose paper we abstracted in our Industrial Notes of last week, are in complete agreement. The attendance at evening classes after a hard day's work in the shops has very frequently proved the hardest condition for the lads to meet; Mr. Gray, in his paper, recognised that fact. On the other hand, we should not be surprised to learn that those apprentices who have either totally or partially failed to attend those classes are among the keenest and the most successful in their everyday engineering tasks. In this connection we may add our conviction that many intelligent lads will obtain a more thorough grasp of theory by the study of chapters on special subjects which appeal to them and are contained in a good treatise—subjects to which their attention has been forcibly drawn in the course of their daily work—than in attending evening classes. Pending, therefore, some solution of this vexed question of class attendance, we should like to be allowed to urge upon works managers to deal leniently with the lads who have not kept strictly to their indentures from this point of view, but who have proved themselves otherwise to be satisfactory and intelligent apprentices.

With reference to the difficulties which were being increasingly experienced by firms working under the Munitions Acts, Mr. W. L. Hichens, speaking a few days ago at Sheffield, said the firms were accountable under two Acts, and were liable either for the excess profit tax under the Finance Act or the munitions levy, whichever was the higher. This administrative scandal—for it deserved no other name—had given a vast amount of unnecessary trouble and had caused a great waste of time, money and labour during a period when there was urgent need to economise all three, and he hoped the first financial act of the new Government would be to return to saner and juster methods of taxation.

General Field-Marshal von Hindenburg has sent the following message to the Chief of the War Office regarding the strike of workmen in a number of Berlin factories:—

"I learn that with few exceptions work has been resumed. The whole of the population is hard hit by the necessary decrease of the bread ration, but I do not doubt that the increase of the meat ration and the regular delivery of potatoes may be considered as compensating for it. I hold it for assured that the collection and distribution of these foodstuffs amongst the people and the promises of the authorities, who are thoroughly cognisant of the seriousness of the situation, will be fulfilled. For this reason I am quite at a loss to see how the food situation at home can be made the ground for strikes amongst the workers whilst the present position on the west front, and which must be fought out there, demands the undiminished production of war supplies of all kinds. This is the first task, which takes precedence over all others. Each strike, however small it may be in appearance, means an unjustifiable weakening of our defensive force, and represents an inexpugnable crime against the fighting forces, but more especially against the men in the trenches, who must bleed as a consequence."

This appeal to the feelings of responsibility and the consciousness of duty amongst the working classes has been forwarded to the workmen's associations with a note annexed by General Groener.

Sunday labour is, as far as possible, to be abolished in a large majority of the establishments controlled by our Ministry of Munitions, from the beginning of May. A communication to this effect is being addressed by the Ministry to the firms concerned, and steps will be taken forthwith to bring the change into operation as smoothly as possible. Establishments in which the process worked is of necessity of a continuous nature will not come within the operation of the new Order, and an exception will also be made in the case of firms whose contracts are of great urgency. Such firms, after consultation with the Ministry, may have recourse to Sunday labour, but on the understanding that it will be dispensed with as soon as the required output has been obtained. Further, shifts beginning on Sunday night or ending on Sunday morning will be continued, and in all cases provision will be made for work connected with the necessary repair of plant and machinery.

The abolition of continuous Sunday labour in the national factories and in the controlled establishments in the Tyne and Tees areas has in most cases been highly beneficial, and it is believed that an extension of the experiment made during the past four months will have equally good effects on the health of the workers and the output of munitions.

With reference to the recent national wages award in the engineering and foundry trades, the Committee on Production considered, on Wednesday, the 18th inst., the special circumstances obtaining in the Coventry district, and in view of the fact that the general advances previously granted to the premium bonus and piece workers on their time rates have not exceeded 5*s.* per week, they have decided that these workers shall receive a further advance of 2*s.* per week on their time rates, such increase to operate as from April 1 last, and to be regarded as war wages and recognised as due to and dependent upon the abnormal conditions now prevailing. This advance is in addition to the 5*s.* awarded under the national award. It is intended to be added to the time rates of premium bonus workers, but will not affect piece prices.

The report for April issued by the Steam Engine Makers' Society says that two very serious and regrettable stoppages of work had taken place on the Tyne and at Barrow. The feeling displayed in the latter area and the gross and vile abuse heaped upon those who were the democratically elected representatives of trade unionism, and who ventured to render service on the spot, showed a state of things which, if generally pursued, would assuredly end trade unionism as a power for good.

In concluding his annual report for the year 1916 Mr. William Mosses, the secretary of the United Pattern-makers' Association, asks why, after the war, should there be an industrial Armageddon at all. There was nothing in the present situation, nor in the situation likely to arise after the war, to justify strife between workmen and employers. Employers and workmen, peer and peasant, had laid down their lives in a common cause. Would it be too much to expect that those who survived and who were knit together in one common bond of sympathy, and too often of sorrow, should shake hands over the sacred relics of these great sacrifices, and, forgetting the squabbles of the past, mutually agree to a united and harmonious future? All that was wanted was confidence, forbearance and faith. Let the workman give of his best, a fair and a full day's work for a fair day's pay; let the employers remember that their workmen were flesh and blood like themselves and not merely part of their profit-making machines, but having the same feelings, inspirations and ideals as themselves, and only lacking opportunity to achieve a position equal to that of their more favoured fellow-countrymen. If the sacrifices on the battlefield resulted in a higher conception of the responsibility of one class to the other and in the eventual breaking down of the suspicion and uncharitableness which too often characterised the relationship between employers and workmen, it would not have been in vain that the multitude of our fellow-countrymen of all denominations had laid down their lives for justice and freedom; their death would at the same time have paved the way for such a reconciliation between capital and labour as would ensure that measure of industrial peace without which the true progress and prosperity of this community was impossible.

The Ministry of Munitions directs attention to the fact: (1) That aliens in the United Kingdom may not take up or be engaged for work connected with the production of munitions except through a Board of Trade Employment Exchange; and (2) that it is an offence for an alien to take up such work, or for a firm to employ on such work aliens to whom the Ministry has not granted a permit to work on munitions. These regulations apply not only to controlled establishments, but to all firms engaged on the production of munitions of war under the Munitions of War Acts, 1915 and 1916.

In this connection it must be understood that this regulation applies to all aliens working in munitions factories, whether as ordinary workmen or voluntary or week-end workers, and the attention of employers is called to the fact that they must satisfy themselves as regards voluntary or week-end workers that all such persons are either British subjects or have obtained from the Ministry of Munitions a permit to work on munitions. This restriction applies to all classes of volunteers, whether National Service Volunteers, or volunteers whose employment is arranged for by a local agency.

THE LATE MR. GEORGE G. WARD.—It is with regret we have to record the death from heart failure of Mr. George G. Ward, deputy-chairman of Messrs. Davidson and Co., Sirocco Works, Belfast. The sad event took place suddenly on the 22nd inst. at his residence at Craigavad. Mr. Ward, who was 56 years of age, had been at business last Saturday, and was in his usual health on Sunday, but was suddenly taken ill during the night. He was the eldest surviving son of the late F. D. Ward, and began his business career with the well-known firm of Marcus Ward and Co., where he served his time and eventually held a prominent position. He joined the Sirocco Works 21 years ago, and was appointed a director when the company became a limited concern in 1898.

THE INSTITUTION OF CIVIL ENGINEERS.—At the annual general meeting of the Institution of Civil Engineers, held on Tuesday evening, April 17, the result of the ballot for the election of officers was declared as follows:—President: Mr. William Barton Worthington (Derby). Vice-Presidents: Mr. John A. F. Aspinall (Liverpool), Mr. Harry E. Jones (London), Sir John Purser Griffith (Dublin), Mr. John A. Brodie (Liverpool). Other Members of Council: Dr. Charles C. Carpenter (London), Dr. Dugald Clerk, F.R.S. (London), Colonel R. E. B. Crompton, C.B. (London), Mr. Maurice Deacon (Matlock), Sir Archibald Denny, Bart. (Dumbarton), Mr. William H. Ellis (Sheffield), Sir Robert R. Gales (India), Mr. A. J. Goldsmith (Queensland), Sir Robert A. Hadfield, D.Sc., M.Met., F.R.S. (London), Brigadier-General B. H. Henderson (London), Mr. Robert W. Holmes (New Zealand), Professor Bertram Hopkinson, C.M.G., F.R.S. (Cambridge), Mr. G. W. Humphreys (London), Mr. Summers Hunter (Tynemouth), Dr. W. H. Maw (London), Mr. Charles L. Morgan (London), Mr. Basil Mott (London), Sir Henry J. Oram, K.C.B., F.R.S., Engr. Vice-Admiral (London), Mr. Frederick Palmer, C.I.E. (London), Captain H. P. R. Sankey, C.B., R.E. (ret.), (London), Sir John F. C. Snell (London), Mr. E. F. C. Trench (London), Mr. William F. Tye (Canada), Sir Philip Watts, K.C.B., LL.D., F.R.S. (London), Mr. Edward J. Way (South Africa), Sir Alfred F. Yarrow, Bart. (London). This Council will take office on the first Tuesday in November, 1917. The Council of the Institution of Civil Engineers have made the following awards for papers read and discussed during the session 1916–17:—Telford gold medals to Messrs. G. W. Humphreys and J. B. Ball (London); George Stephenson gold medals to Messrs. P. V. O'Brien and John Parr (Perth, W.A.); Telford premiums to Messrs. P. V. O'Brien (Perth, W.A.), J. L. Hodgson (Luton), W. Brown (Glasgow), and P. M. Crosthwaite (London); and a Crampton prize to Mr. F. J. Waring, C.I.E. (London). The awards for papers published in the Proceedings without discussion will be announced later.

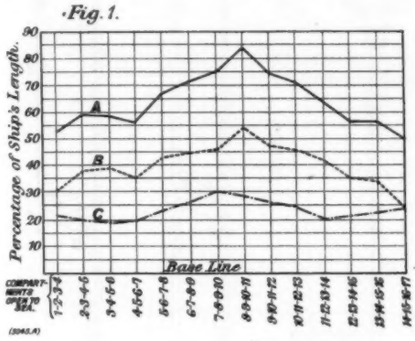
THE CLOSING OF SIDE APERTURES IN SHIPS FROM THE BRIDGE.*

By ING. E. BENVENUTI.

ONE of the main principles formulated by the International Convention of London in regard to the design of ships was that the maximum length of each transverse watertight compartment must be proportional to the length of that portion of the hull, having its centre at the middle point of the compartment, which may be open to the sea without sinking the ship beyond a certain margin line. In this connection it should be remembered, however, that the ratio between the spacing of transverse watertight bulkheads and the floodable length has for many years been taken into account in the design of passenger steamers, particularly in the design of ocean-going liners, owned by large steamship companies. In this class of vessel it has been usual for the leading steamship companies to require, either from their own naval architect or from shipbuilders, that new ships should still retain a stipulated freeboard should one or more adjacent transverse watertight compartments become flooded.

It may also be added that the stipulations in regard to floatability and freeboard in damaged conditions, made by the steamship companies, for transoceanic passenger liners are, as a general rule, much more rigorous than those fixed by the International Convention. For example, for a ship primarily engaged in carrying passengers and having a length at the load waterline equal to, say, 600 ft., the Conference Regulations state, under Article 8, that the maximum length of the transverse watertight compartments must not be more than 0.422 of the floodable length of the ship.

Fig. 1.



——————— Percentage of ship's length open to sea by the damage.

- - - - - - - - - - - Additional percentage of ship's length which may be flooded in consequence of the sinkage of the sidelights of the undamaged compartments.

——————— Total percentage of ship's l ngth either flooded or which may be flooded.

That is to say, the ship, under the practical conditions of permeability of the various compartments assumed by the Convention, must be able to remain afloat when two of her compartments are open to the sea and the two compartments adjacent to these are filled with a quantity of water about four-tenths of their total capacity, taking into account their permeability.

In comparison with the above requirements it may be pointed out that there are already existing ships, having the load waterline length referred to, which are to be able to remain afloat with three transverse watertight compartments open to the sea, and there are under construction for the Navigazione Generale Italiana ships of this length which will be able to remain afloat with four transverse watertight compartments open to the sea. These ships, designed before the report of the International Convention was published, show that the leading steamship companies, fully realising the moral responsibility undertaken by the owners of passenger ships, have not only freely adopted for several years past one of the main principles stated by the Convention, but have adopted that principle in a much more rigorous manner than was prescribed by the Convention.

The actual design and construction of the new vessels building for the Navigazione Generale Italiana, the dimensions of which will probably be those of many passenger ships in the near future, also demonstrate that it is possible for the naval architect to design a ship which will comply with all the requirements of the steamship companies in regard to passenger accommodation and suitability for a particular trade, and also present a degree of safety in damaged conditions far greater than that demanded by the International Convention. It is sufficient for this purpose to adopt a sufficiently high ratio between the moulded depth to the bulkhead deck and the fully loaded draught, as the calculations in regard to transverse stability under different conditions of lading show that, with the usual values of the breadth adopted in vessels of this type, there may be, corresponding to some initial conditions of the ship when undamaged, a sensible list at the beginning of the flooding, but that the ship will have sufficient transverse stability when the compartments are flooded to sea-level.

But it is most important to note that the above conclusions on the safety of ships in a damaged condition depend largely upon the supposition that, whatever be the damages sustained by the hull, water cannot enter into any other watertight compartments than those aggregating the floodable length of the vessel corresponding to the damaged part of the hull. This is, for a passenger ship, a supposition which is capable of realisation only under exceptional conditions, as hygienic necessities of comfort have turned the sides of every large modern liner into veritable sieves, owing to the hundreds of apertures made through the skin below the bulkhead deck.

Generally speaking, these apertures are of two kinds—overboard discharges, and light and air apertures; but they all provide likely means of ingress for water to the inside of the ship in the event of an accidental increase beyond the load draught of the ship.

The first and most important effect of the flooding of any portion of the vessel is to increase the draught of the ship, either uniformly or with a change of trim depending upon the location of the damage. In either case an important fact arises in regard to the undamaged compartments of the ship, viz., the inner apertures of the overboard discharge pipes as well as the sidelights, which before the damage occurred were above the waterline, become in many cases submerged. The time required for such a sinkage, as well as the length of the portion of the hull for which the sidelights and the apertures of the discharge pipes become submerged, depend upon many circumstances differing for each special case.

Referring to the first point, experience has shown how, in many cases of extensive damage, particularly owing to the unavoidable list of the ship when flooding, only a few minutes elapse between the time of the damage and the submersion of the apertures. Referring to the second point, I think it interesting to give in Table A the results of calculations relating to the various trims of a ship having a watertight subdivision suitable for assuring her floatability with four adjacent transverse watertight compartments freely open to the sea in the case of a ship having the following principal dimensions:—

	ft.	in.
Length between perpendiculars ...	601	0
Breadth moulded over frames ...	76	0
Moulded depth to bulkhead deck ...	50	2
Load draught	28	0
Sheer at bulkhead deck forward ...	12	3
Sheer at bulkhead deck aft ...	4	10
Minimum height above low water-level of the sill of sidelights in the first 'tween deck	19	0
Ditto for the sidelights of the second 'tween deck	19	6

The sidelights of the third 'tween deck, being supposed to be kept permanently closed at sea, have not been taken into account, and the vessel was supposed not to list over more than 10 deg.

The results given refer to the various possible groups of four adjacent transverse compartments flooded, and they undoubtedly deserve the closest attention, because they give an exact idea of the real conditions of safety of the ship in a damaged condition. They clearly show how, in consequence of the flooding of a portion of the vessel, there are from four to ten undamaged watertight compartments, the sidelights of which become submerged, and these consequently may be, either entirely or partly, invaded by water passing through some open sidelights. The same information is shown graphically in Fig. 1.

The calculations dealt with relate to a vessel of a special design with exceptional watertight subdivision, large sheer and a very considerable height above the line of the lowest row of sidelights which may be open to the sea, so that we must conclude that the real safety conditions of nearly all the vessels now afloat or building, should damage occur to their hull, will prove inferior to the case referred to. The above conditions would appear yet worse if we consider the possibility of some undamaged compartments being flooded through overboard discharge pipes, because the apertures of these pipes inside the vessel are not, as a rule, more than 2 ft. or 3 ft. above the deck. The striking results of the calculations summarised in Table A lead therefore to the conclusion that in all probability if damage were sustained which opened to the sea a group of compartments not totalling the floodable length of the ship, this would cause her loss if all side apertures were not, at the moment of the damage, either already closed or immediately closed.

Both the International Conference which met in London in November, 1913, and the Bulkhead Committee appointed by the Board of Trade took into consideration the influence of the side apertures of a vessel upon her practical safety in damaged conditions. Article 23 of the Convention states that as a general rule all sidelights and overboard discharge openings must be fitted with suitable means for closing them, and must also be arranged in such a manner as to prevent, as far as possible, the accidental admission of water into the ship. With special reference to sidelights, Article 16 of the Regulations annexed to the Convention states the sidelights below a deck, the underside of which at its lowest point (at side) is less than 7 ft. above waterline, must be kept permanently closed at sea. The article also forbids the fitting of sidelights in spaces exclusively devoted to the carriage of cargo or coal.

With reference to the overboard discharge apertures, the aforesaid article, besides requiring the largest possible grouping of the discharge pipes, also requires that discharges led through the skin from spaces below the margin line shall be fitted either with one valve that can be worked from a distance or with two valves, one of these being always accessible.

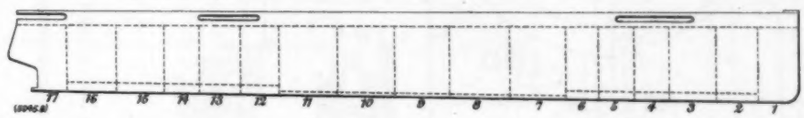
These requirements aim at increasing the limit of sinkage and inclination of the vessel at which water would eventually enter the undamaged compartments through open sidelights or discharge pipes, and also tend to increase the possibility of a closure of all sidelights and discharge openings when the ship suddenly and greatly increases her draught by listing over or changing trim, thus making it difficult for the crew to reach the compartments below the weather deck.

In modern transatlantic liners the machinery, the bunkers, and the numerous passenger and deck services require a very large amount of space on board such ships, and consequently, in order to ensure a profitable working of the vessel, it is necessary to fit passenger

TABLE A.

Length at low water level, 622 ft.
Moulded depth to bulkhead deck, 50 ft. 2 in.
Draught before damage—For damage to forward compartments, 28 ft. even keel.
Draught before damage—For damage to after compartments, 27 ft. forward and 29 ft. aft.

PERMEABILITY OF DAMAGED COMPARTMENTS AS PER INTERNATIONAL CONVENTION—MAXIMUM LIST 10°.



Compartments Open to Sea.	Draught in Damaged Conditions. Fore.	Middle.	Aft.	Undamaged Compartments having their Sidelights Submerged.	Portion of Hull either Flooded or which may be Flooded. Flooded by Damage.		Which may be Flooded owing to some Sidelights being Open.		Total.	
	ft. in.	ft. in.	ft. in.		ft.	per cent. L. about	ft.	per cent. L. about	ft.	per cent. L. about
1-2-3-4	41 6	31 7	21 6	5-6-7-8-9	136	22	189	30.5	325	52.5
2-3-4-5	49 6	34 3	19 2	1-6-7-8-9-10	130	21	241	39	371	59.5
3-4-5-6	52 7	35 8	18 8	1-2-7-8-9-10	122	19.5	249	40	371	59.5
4-5-6-7	52 6	36 7	20 8	1-2-3-8-9-10-11	127	20.5	288	36.5	415	66.5
5-6-7-8	51 5	37 3	23 5	1-2-3 4-9-10-11	142	23	273	44	415	66.5
6-7-8-9	48 0	37 9	27 2	1-2-3-4-5-10-11-12	163	26	283	45.5	446	71.5
7-8-9-10	42 9	37 7	32 8	2-3-4-5-6-11-12-13-14	183	29.5	290	46.5	473	76
8-9-10-11	35 8	38 1	40 0	4-5-6-7-12-13-14-15-16-17	183	29.5	344	55	527	85
9-10-11-12	30 5	36 4	42 3	6-7-8-13-14-15-16-17	168	27	302	48.5	470	75.5
10-11-12-13	26 0	35 3	44 8	7-8-9-14-15-16-17	154	25	289	46.5	443	71
11-12-13-14	22 6	34 6	46 7	8-9-10-15-16-17	134	21.5	266	43	400	64
12-13-14-15	19 8	32 6	45 7	9-10-11-16-17	131	21	223	36	354	57
13-14-15-16	17 5	32 4	47 8	9-10-11-12-17	139	22.5	215	34.5	354	57
14-15-16-17	28 2	31 2	34 2	10-11-12-13	153	24	154	25	307	49.5

* Paper read at the Institution of Naval Architects, March 28, 1917.

accommodation also in the lowest 'tween decks. Fast liners having passenger and crew accommodation distributed in three 'tween decks below the upper deck are very usual, and will undoubtedly be more usual in the near future. Increasing demands for comfort will, moreover, necessitate in new passenger ships that sidelights of the lowest accommodation should be allowed to be kept open in fine weather at sea. That is to say, liners of the future will have three rows of open sidelights below the upper deck, which deck will also very often be the bulkhead deck, in order to avoid an excessive transverse subdivision of the hull. Further, the height of the lowest row of sidelights will often be small, corresponding to a height of the lowest point at side of the second deck below the upper deck equal to 7 ft. above the waterline.

Of course, in the above conditions, the immediate closure of the sidelights on the spot by hand will prove practically impossible, as many cabins are kept locked at sea, while other spaces on board are used as stores.

With regard to sidelights, we are consequently led to conclude that a modern passenger liner will in practice only realise the degree of safety at sea in damaged conditions for which she was designed provided (*a*) either all the sidelights fitted below the bulkhead deck are kept permanently closed at sea, (*b*) or a suitable and reliable arrangement for controlling all sidelights from the bridge or other central station is fitted on board. If one of the above conditions is not fulfilled, the degree of safety in damaged conditions of the ship arrived at from her flooding calculations will only have a theoretical value.

It is well known, however, that in the practical working of a passenger ship the first condition cannot be fulfilled, no matter what the climate is in which the vessel trades or the ventilating system installed on board. Passengers, and particularly cabin passengers, expect to be allowed to open the sidelights of their rooms, and very often refuse cabins having fixed sidelights or, at any rate, are only prepared to pay a low price for such rooms. It is therefore necessary to fulfil the second condition, and this would doubtless have been stipulated by the Convention or by the Bulkhead Committee had a suitable controlling arrangement been already devised at that time.

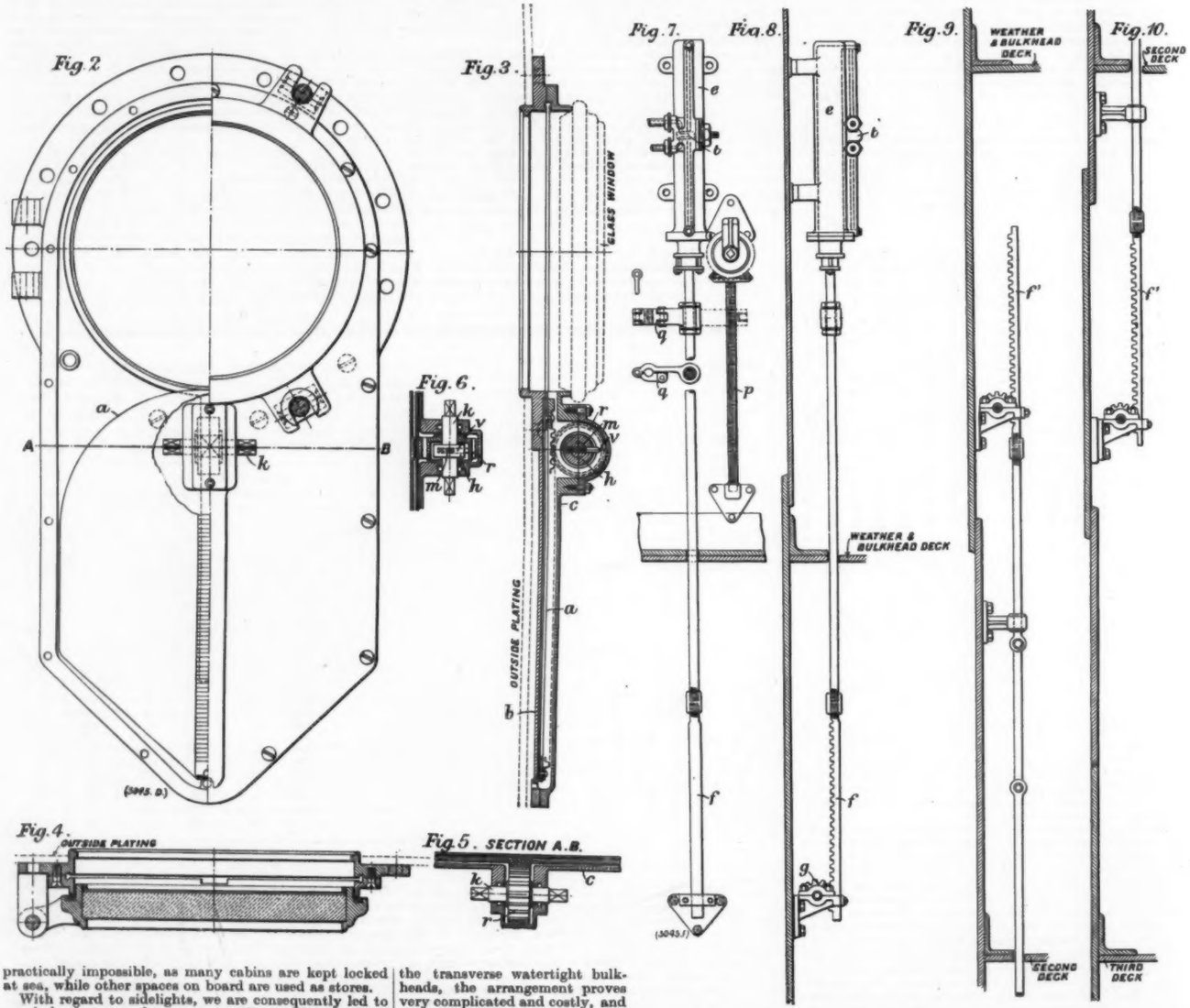
With reference to the overboard discharges, although these have a much smaller diameter than sidelights, and are fitted with storm valves, and are always connected to inside pipes of small diameter, the question of the reduction of their number as well as that of closing them in any emergency at sea is a very important one. A radical method for reducing to a minimum the number of the skin apertures is one, also given in the first report of the Bulkhead Committee, which consists in fitting in each watertight compartment, or in each group of watertight compartments, a drainage system having a collecting tank and suitable pumping arrangements. But the fitting of such an arrangement involves the addition of other mechanisms to the already numerous devices existing on board modern large passenger ships, and as it is not desirable to carry large pipes through the transverse watertight bulkheads, the arrangement proves very complicated and costly, and also requires two apertures in the skin of each of several compartments, because of the convenience of draining into separate collecting pipes and tanks the baths and wash-basins, and the nests of w.c.'s, even though use may be made of syphons on the separate discharges.

In my opinion, for nearly all passenger ships it is possible, without having recourse to such a complicated plant, to make a sufficient reduction in the number of the overboard discharge openings by the following arrangement:—(*a*) Lead all water discharges from the deck below the bulkhead deck to the bilges of the corresponding watertight compartments; (*b*) group all the soil pipes from the nests of the w.c.'s fitted in each watertight compartment into one overboard discharge; (*c*) fit in each transverse watertight compartment two inclined collecting overboard discharge pipes in the 'tween deck immediately above the waterline, one on each side on the face of the reversed frames, into which all scuppers and water discharges must drain from the bulkhead deck and the decks above in way of the compartment. Into these collecting pipes the soil pipes of the private w.c.'s may also discharge, provided the number of the latter be not too great. Of course in these collectors there must be a continuous circulation of salt water from the sanitary service.

With the arrangement just described the overboard discharge apertures will generally be reduced to two for each watertight compartment, and only in the compartments in which nests of w.c.'s are fitted will there be three or, very seldom, four skin apertures required for discharges. By fitting to each aperture a skin sluice valve, the plant will prove as suitable and practical as that requiring special pumping arrangements, while certainly simpler and more economical in first cost and upkeep. With reference to the possibility of closing the overboard discharge openings in an emergency, it may be a matter for discussion whether the fitting to each aperture of a skin sluice valve worked from a deck above the bulkhead deck, in addition to the usual storm valve, represents the best device for the safe closing of these openings. But I must say, having designed such an arrangement for large liners now building, the result proved so complicated and costly in regard to the control rods and gears for the sluice valves that I do not recommend the installation of such a system. Another and greater disadvantage of such an arrangement is that in an emergency at sea a great deal of time and a number of persons will be required for the closing of all the sluice valves owing to the unavoidable distribution of the control wheels throughout the full length of the ship, often in places not always easily and rapidly accessible to the crew.

Consequently we must conclude, as in the case of the sidelights, that it is necessary to have a suitable and reliable arrangement for the simultaneous closing from the bridge of all valves fitted on the overboard discharges, in order to ensure that the pressure of the latter will not diminish the degree of safety in damaged conditions guaranteed to the ship by her watertight subdivision.

The arrangement here described for the simultaneous closing from the bridge of all sidelights and overboard



discharge apertures presupposes that the ship is fitted with the usual hydraulic plant for controlling the watertight doors from the bridge, as such a plant must now necessarily be provided in a modern liner owing to the requirements of the International Convention and the recommendations of the Bulkhead Committee in regard to the closing of the watertight doors. If such a plant be not available, a special small hydraulic plant would require to be added.

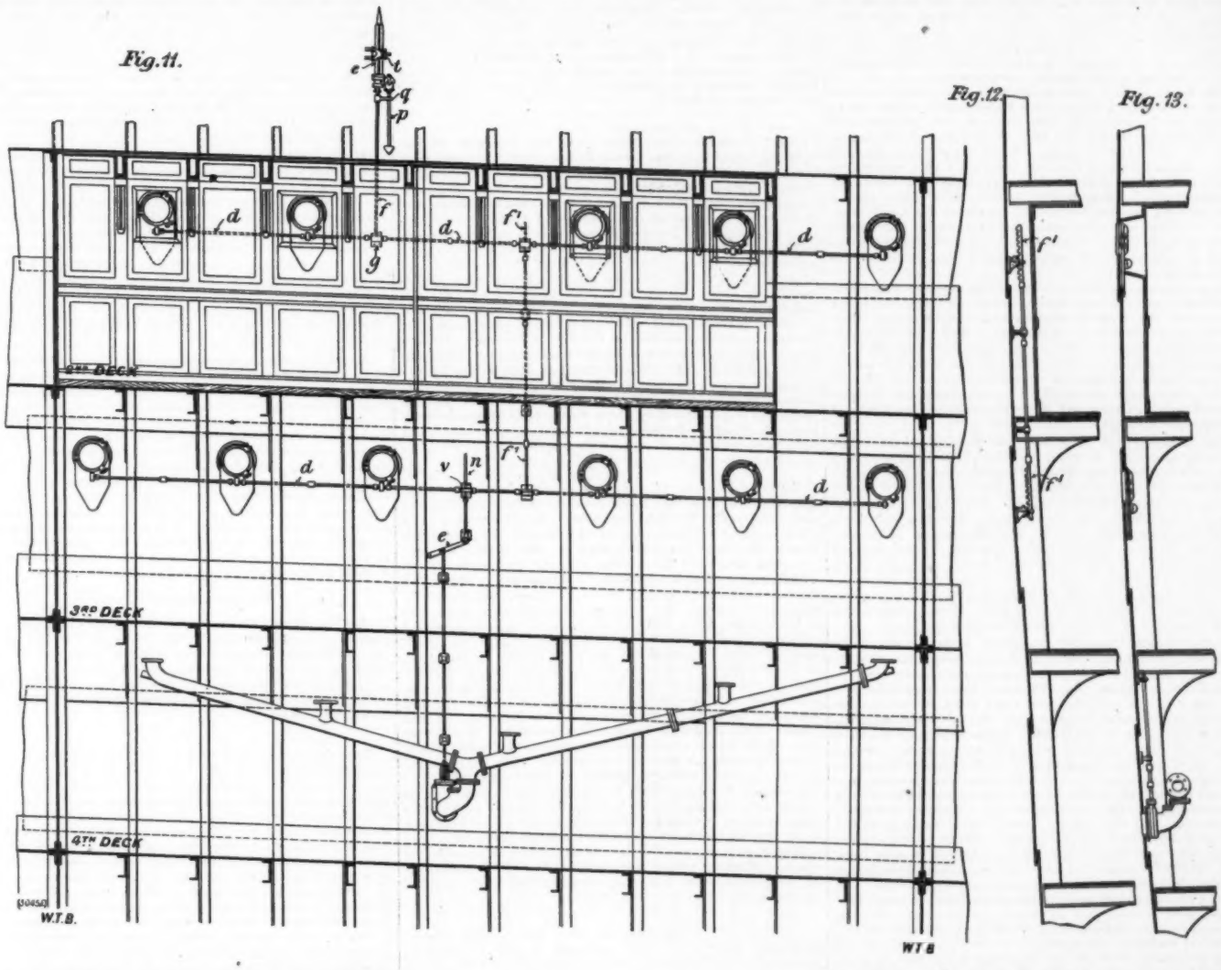
The principal features of the proposed arrangement are :—(*a*) The fitting to each sidelight or skin aperture of a sliding shutter ; (*b*) the fitting, corresponding to each transverse watertight compartment, of a mechanism for closing the shutters, these mechanisms being identical in design for all compartments but quite independent of one another in regard to their working.

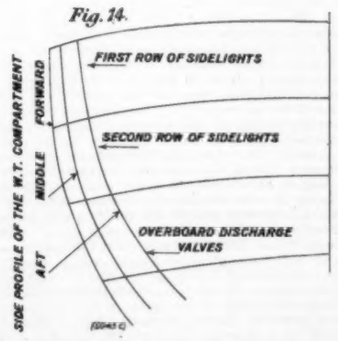
The proposed type of sidelight is shown in Figs. 2 to 6, page 398, and is fitted with a sliding shutter *a* made in gunmetal. The shutter, sliding in a vertical direction, closes the sidelight opening outside the glass, the closing being practically watertight, and it also protects the glass against breakage by objects floating near the ship. The illustrations show how the hinged part of the sidelight remains as usual and may also be fitted with a deadlight. The fixed part of the sidelight, however, is different from the usual practice and has an appendage *b*, which forms a case for the shutter when the latter does not close the sidelight opening. The shutter is worked by a rack and pinion gear, the rack being riveted to the shutter, while the bearings of the axis of the pinion *r* are cast solid with the cover *c* of the case. The ratio between the diameter of the pinion and the stroke of the shutter is identical for all the sidelights in the ship, so that the closing of the latter requires an equal number of revolutions for all the pinions, actually about 1½ or 2 revolutions.

The illustrations clearly show how the sliding of the shutter is quite independent of the opened or closed position of the hinged part of the sidelight. That is to say, the shutter only represents an additional closing arrangement for the sidelights, suitable for emergency use at sea, and leaves quite unaltered the usual working condition of the sidelight. The sidelights remain under the control of the passengers and crew, and it is immaterial whether, at the instant when the shutter must be closed, the glass window is open or not.

It must be noted that the proposed closing is only for emergencies ; and although with careful workmanship the closing by the shutter may be made practically watertight, it must be remembered that absolute watertightness is not essential, as the proposed arrangement has for its aim, when damage to the skin occurs, to prevent, by a rapid control from the bridge, any appreciable quantity of water entering the undamaged compartments of the ship by passing through those of the sidelights which may be open at the instant of the damage and which may be situated in places not easily and rapidly approachable by the crew. As a rule, after closing the shutters from the bridge, the crew must then close by hand all glass windows and deadlights, but it is evident that the safety of the ship will not be compromised either because of time being required for that measure, or by the practical impossibility of closing some of the glass windows.

Figs. 11 to 13, above, show how all shutters of the sidelights of one transverse watertight compartment fitted on each side of the ship may be closed simultaneously. It will be seen that the vertical spindles of the pinions working the shutters of the sidelights fitted on each side in each 'tween deck of a compartment are actuated by a horizontal shaft consisting of small horizontal rods *d* passing through the frames of the vessel. The various horizontal shafts are next connected up to a small vertical hydraulic cylinder *e* (Figs. 7 and 11) against the plating, this cylinder being worked from the bridge by hydraulic power. The piston rod of each cylinder actuates a rack *f* (Fig. 8) engaging with a main pinion *g* on the horizontal shaft controlling the shutter pinions of the upper 'tween deck. The two horizontal shafts of the 'tween decks are connected by a system of two racks f^1 (Figs. 9 and 10) and a rod between them, so when one shaft turns the other shaft turns also. It will thus be readily understood that by turning a handle in the wheel-house, the pistons of the hydraulic cylinders fitted in each compartment actuate, through the racks *f* and f^1 and the main pinions *g*, the horizontal shafts for the various 'tween decks and thus close simultaneously all the sidelight shutters. By reversing from the bridge the pressure in the hydraulic system, the pistons of the small cylinders move in the opposite way and consequently open all the shutters.





To prevent failure of the system through an obstacle preventing the closing of one shutter, and in order to avoid serious injury to any one who might have an arm or head through the light at the time of damage, each shutter is provided with a slip coupling by means of which the shutter will be thrown out of gear should the normal pressure in the hydraulic system not suffice to close it.

The details of the slip coupling referred to are shown in Figs. 3 and 6, page 398. It will be seen that the portion *k* of the horizontal shaft which forms the spindle of each pinion passes freely across the latter. The spindle is provided with a collar *h* which is arranged in a corresponding recess in the pinion. In the collar *h* is fitted a small pin having a conical head which projects into a small groove cut into the rim of the pinion, through the action of a spiral spring *m*, thus ensuring that with a normal pressure the pinion will engage with the spindle and actuate the shutter. Should, however, the strain become too severe owing to any exceptional resistance preventing the sliding of the shutter, the head of the pin slides on the inclined surface of the groove, thus forcing back the spring and disconnecting the pinion from the horizontal shaft, which remains free to turn and control all other shutters, leaving only the obstructed sidelight shutter open.

Fig. 11 also shows how easy it is with the arrangement now proposed to also close from the bridge the overboard discharge apertures. For this purpose a sluice valve must be fitted on each aperture between the usual storm valve, which sluice valve remains open at sea. For controlling the sluice valve from the bridge at the same time as the sidelight shutters, it is sufficient to fit a

pinion like that working each sidelight shutter on the horizontal shaft of the lowest 'tween deck, and a rack *n* engaging that pinion and controlling a lever arm *e* having its fulcrum attached to the ship's skin and directly working the valve rod. A slip coupling of the design already described, fitted between the pinion and the horizontal shaft, will leave the latter free to turn should an obstacle accidentally prevent the sluice valve closing.

The proposed arrangement is also suitable for immediately closing by hand, from the upper deck, each group of sidelights and overboard discharges fitted in the watertight compartment. For that purpose it is sufficient, as shown in Figs. 7, 8 and 11, page 399, to fit near the piston rod of the cylinder a screwed rod *p* having fixed ends which may be turned by a handle, and also to fit on the piston rod a turning arm *q*, the free end of which may work as a female screw on the rod *p*.

By making the arm *q* engage with the screw *p*, it is possible to work the piston rod by hand and consequently also all the horizontal shafts connected to it.

The small cock *t*, cast solid with the cylinder, is so made as to allow, during the hand control, free communication between the two ends of the cylinder and simultaneously to cut out the connections of the latter with the hydraulic pipings. Such an arrangement of hand control fulfils in the best possible way the requirement of the International Convention that all valves on overboard discharges should be controlled from places situated on a deck higher than 7 ft. above the low water-level, for with the proposed arrangement all the valves fitted on each side of the ship within a watertight compartment would be controlled from a station above the bulkhead deck.

An experimental plant similar to the one now described was fitted in the last after watertight compartment but one of the large liners whose flooding calculations have been referred to in this paper: that plant includes 12 sidelights distributed in two 'tween decks and an overboard discharge valve. The portion of hull in which the plant is fitted has the shape shown in Fig. 14, yet the working of the whole plant proved very satisfactory from all points of view and the fitting of it in place did not present any difficulty.

The arrangement described for closing all the skin apertures is open to criticism, in that the sudden breaking of a cylinder or of the branch pipes to the latter, from a collision or explosion, would cause the pressure to fall throughout the hydraulic system and thus prevent the control from the bridge, not only of the skin apertures but of the watertight doors. For this reason it may be advisable to have separate main piping for the control of the doors or a small automatic valve could be fitted at each point where a pipe to a cylinder branches from the main piping, these valves being so arranged as to shut off the flow of water from the main piping should the pressure in any of the branches suddenly fall.

It is evident that the proposed arrangement fully solves the problem of the immediate simultaneous closing from the bridge of all ship side openings in any emergency at sea, but in order to judge of the advisability of installing the system in a modern passenger ship we must also consider the questions of reliability, first cost and upkeep.

With reference to reliability, it should be noted that even for a large liner the proposed arrangement entails nothing more than the fitting in each transverse watertight compartment of two very simple installations, one on each side, these installations being identical with each other and with the installations for all the other compartments of the ship. Each installation works independently from all the others, although they are all connected to the same main piping. As will be seen from Figs. 7 to 10, the various parts are plain and simple in design and are efficiently and strongly connected together. The moving parts are few and their movements are small and simple, and not subject to shocks or reversals of load. The motive power, hydraulic, is the most reliable we can desire. Provided the upkeep of the packings of the small pistons and of the rod stuffiing-boxes be regularly attended to, no part of the whole plant should fail to work well. Another advantage of the arrangement is that the parts can be easily protected from interference by passengers. In fact the sidelight shutters remain concealed in a metallic box, and the sluice valves also remain hidden in their boxes. Both the hydraulic cylinders and the controlling gears are fitted near the plating, within the depth of the frames, and are thus concealed by the inside lining in cabins, while in compartments having bare plating the whole plant may be readily protected by wood lining fitted over the frame space where the cylinder and the racks are placed, and by a batten fitted in front of each horizontal shaft.

With reference to the question of initial cost, it is, of course, evident that the proposed arrangement will prove more costly than the usual arrangement of plain sidelights and overboard discharges, the increase in cost depending more or less upon the care bestowed upon the workmanship and the quality of materials used. I may say that estimates made by first-class firms for first-class plants to be fitted on board passenger ships having about 400 sidelights and skin valves to be controlled from the bridge show that the extra cost does not reach 1¼ per cent. of the total cost of the vessel: that is not a big figure to pay for the greatly increased safety of the vessel in damaged conditions—that is, for the possibility of converting the hull of the vessel, in any emergency at sea, into a hull without any aperture in the undamaged compartments, and thus fulfilling in fact the fundamental hypothesis on which the calculations referring to her floatability in damaged conditions are based.

With reference to the upkeep of the plant, this entails only the overhauling of the piston and rod stuffing-box packings. Owing to the very small movement of the different parts, lubrication is not needed, especially if, as is advisable, pinions, racks, pinion bearings, and rod guides are made of bronze or are bronze lined. Neither the sidelights nor any other part of the plant require any special survey or upkeep other than the usual inspection and cleaning periodically required by every plant on board a vessel when lying in harbour. If the precaution is taken to fit loose sheathing in contact with the moving parts, the periodical overhauling and cleaning will not present any difficulty.

THE NORWEGIAN REINFORCED-CONCRETE SHIPBUILDING INDUSTRY.—When the building of reinforced-concrete vessels was commenced in Norway there were many sceptics, and there are probably some still, but the Fougner venture seems in any case to have turned out a success. A dividend of 10 per cent. has been declared for the first half-year, and the capital has been increased to a minimum of 1,500,000 kr. and 2,000,000 kr. maximum. The company has taken over all Mr. Fougner's foreign patents, and affiliated companies are to be started in different countries.

NEW CUNARD BUILDINGS.—On the occasion of the opening of the new Cunard Building we published (vol. ci, page 582) some notes on the building to show that it was worthy of the great company which it housed, and that its imposing and central eminence was thoroughly justified by the position of the Cunard Company amongst the Liverpool and, indeed, imperial organisations. There has just been published by the company a handsome volume fully describing the building and illustrated by most effective reproductions from photographs by Messrs. Bedford Lemere and Co., 147, Strand, London, W.C. The description makes the publication of great interest, and this is enhanced enormously by several contributions on the history of Liverpool and its port, with appropriate illustrations, dating from the seventeenth century. Great care has been taken by the compiler in ensuring the accuracy of the maps and other illustrations, as well as of the historical data, so that the book will be treasured by those interested in the maritime history of Great Britain, which is so closely interlaced with the evolution of our great empire.

BRITISH TRADE.—A meeting of the Advisory Committee to the Board of Trade on Commercial Intelligence was held at 7, Whitehall-gardens, on Wednesday, the 18th inst. The President of the Board of Trade (Sir Albert H. Stanley, M.P.) was in the chair. It was reported that at the recent British Industries Fair, which, owing to war conditions was necessarily restricted to the toy, fancy goods, pottery, glass, printing and stationery trades, the number of exhibitors was 444, as compared with 350 in 1916, and the number of visitors 15,000, as compared with 13,000 in 1916. Reports were presented on the work of the Department of Commercial Intelligence for the first quarter of 1917, and on the arrangements which are in progress for the extension of the official representation of the United Kingdom trade throughout the British Empire. It was stated that over 700 firms had applied for interviews with H.M. Trade Commissioner for Canada, who is now in the United Kingdom on an official visit. The committee approved the arrangements made by the Board of Trade and Foreign Office for special trade inquiries in Spain and Portugal and for the exhibition in various trade centres of samples of foreign goods which compete with British goods in important foreign markets. The committee also considered and approved proposals for the co-operation of the Board of Trade with associations of manufacturers for the investigation of overseas markets.

TELEGRAPH DISTURBANCE BY THE LÖTSCHBERG ELECTRIC RAILWAY.—The opening of the Lötschberg Railway in 1913 seriously disturbed the service on all the Swiss telegraph lines converging at Brig in the Rhône Valley. The Lötschberg railway, the construction of which involved some considerable difficulty, runs from Brig on the Rhône, first fairly parallel to the river and to the State railway skirting it, on the slopes of the northern bank; about 10 km. west of Brig, at Hothen, the electric line then turns to the north, away from the Rhône and the railway. The disturbances were particularly strong during the ascent of the electric trains. All the telegraph lines in the district are single line with earth return. To reduce the disturbances the telegraph department shifted the earthing of the telegraph lines from Brig to Fiesch, about 16 km. east of Brig, that is away from the electric line, the new line to Fiesch being double. Little was gained by this. An investigation was then started by Drs. M. Dutermuth and T. Müller, of the Swiss State Railways, and their illustrated report, which is very instructive, was published in the *Elektrotechnische Zeitschrift* of January 25, 1917. Very striking oscillograms were taken. It resulted that the disturbances were almost entirely electrodynamical; current leakage to earth had very little to do with them. The remedy proposed is rather surprising. The earthing of the telegraph lines was again shifted experimentally, not away from the electric railway to the east, however, but in the opposite direction, to the west. From Brig the Rhône flows westward to Visp, Gampel and Turtmann, all on the State line. When earth was made at Visp the disturbances were reduced by 50 per cent.; at Gampel by 85 per cent.; and at Turtmann, which lies a little beyond the point where the electric railway turns northward, the disturbances practically vanished. The connection between Brig and the point at which earth was made was by a special insulated line. The disturbances were measured at Sivn (Sitten), which lies a good deal further west, down the Rhône valley.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Activity of the most energetic description pervades the steel trade in the West of Scotland, everything giving place to the requirements of Government, on which account practically the whole output is monopolised, either directly or indirectly, to the absolute exclusion of all other claims. Under the circumstances it is almost impossible to prevent deliveries running behind, the majority of the manufacturers finding considerable difficulty in meeting the incessant demands. Although a noticeable increase in output has resulted from the recent improvements and additions to already existing plant, even this has been insufficient to relieve the pressure, nor has it yet been possible to lay up any stock, much as this is desired. Every mill is being employed to its fullest extent, and still the demand for finished and semi-finished material grows. As in every other branch of the iron and steel industry firm prices still hold, steel ship plates being quoted at or about 14*l.* 5*s.* per ton, boiler plates, 15*l.* 5*s.*, and angles, 14*l.* 2*s.* 6*d.* to 14*l.* 5*s.*, while higher levels are not infrequently touched.

Malleable Iron Trade.—The activity in the malleable iron trade is as marked as ever, with every prospect of an assured continuance, at any rate for the duration of the war. Makers report that their entire plant is running at the fullest possible pressure, Government work being first and foremost, and the demand incessant. Indeed, the total output of the steel department in every establishment is entirely reserved for purposes of the war, and after all these requirements have been met the amount available for ordinary mercantile consumers is practically infinitesimal, if even existent. Prices remain firm, and "Crown" bars are now quoted at 15*l.* 2*s.* 6*d.* to 15*l.* 5*s.* per ton.

Scotch Pig-Iron.—Pig-iron manufacturers have become so accustomed now to working on a large scale that the demands made upon them—which would in normal times have occasioned a rather severe strain on their resources—are considered quite in the order of things, and as these increase every effort is put forth in order to keep pace with them. Every furnace is in full blast and, as far as is possible, yielding the maximum output. The local steel works engaged on Government contracts continue to claim a very heavy delivery of hematite, the entire production being speedily absorbed. While some qualities are undoubtedly scarce, foundry grade is in great request. Little change takes place meantime in the current rates of pig-iron, local prices being fixed, and therefore immovable, and export firm.

DANISH STATE RAILWAYS.—Although there is an increase of 4,208,000 kr. in the receipts for the period April–February of the current financial year, as compared with the corresponding period for the previous year, the surplus has receded from 13,123,165 kr. to 3,734,750 kr. owing to the expenses having increased from 51,126,000 kr. to 64,723,000 kr.

THE ALKALI (POTASH) PROBLEM IN GERMANY.—The troubled position of the German alkali industry continues to attract much attention, and several remedies are being advocated. Amongst others, Dr. H. Paxmann, a well-known expert in this branch and himself extensively interested in the industry, advocates a material rise in the alkali quotations, a continuation of the prohibition against the construction of new shafts after the war until an increase in the sales renders the measure an unnecessary one, and sundry other reforms. He looks with favour upon an Imperial alkali monopoly. His methods are denounced as intended to keep going a number of concerns which really have no chance of paying their way and which abound owing to the excessive speculation to which the industry has given rise. And yet Dr. Paxmann admits that of the 250 shafts which in the future will be available, about one-third could be dispensed with. On the other hand, an alkali monopoly would further increase the number of shafts. There are, no doubt, reasons of some weight for the establishment of a State alkali monopoly within the German empire, but a monopolisation price of 1,200,000,000 marks is a somewhat serious item to deal with, and one which the taxpayers would certainly approach in a cautious and circumspect manner.

ELECTRICAL AND ALLIED TRADES DIRECTORY.—We have received a copy of this Directory ("The Red Book") for the current year, the thirty-sixth annual edition, which is published by Messrs. H. Alabaster, Gatehouse and Kempe, 4, Ludgate-hill, E.C., at the price of 1*l.* 1*s.*, post free. The contents are divided into three sections, the British, with 15,330 names; the Colonial and General, with 7,590 names, and the Continental (selected), with 4,550 names. The first and second sections are divided into alphabetical and classified subdivisions, which can easily be referred to by means of a thumb index. Telegraphic addresses, telephone numbers and codes are given in the alphabetical sections, together with financial particulars of British limited liability companies, also of foreign companies having a British address. The list of electricity undertakings in the United Kingdom, British Colonies and some other countries include the following details:—The nature of the supply, system of distribution, capacity of plant, voltage and chief engineer's name, and in the case of alternating current the phase and periodicity are included. A list of specialities appears in the British section, arranged alphabetically according to the name of the article, followed by the maker's or agent's name and address.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The position remains one of much difficulty owing to the inadequacy of supplies of all qualities. The demand for manufacturing fuels is so great that pits are not able to cope with it in a successful manner, and the intervention of the Government-appointed local committee has been necessary in order to ensure that deliveries shall be equitably distributed. The consumption of full tonnage of best steam hards is automatic. Steam nuts, also, are absorbed with great rapidity, and for slacks there is a strong inquiry. Cokes of all grades have a brisk tone, and there is a difficulty in obtaining full supplies. The only relieving feature in the situation, from the point of view of the purveyors, is that the improved weather has relaxed the excessive demand in the house coal section, and depots and merchants are able to overtake the heavy arrears which had inevitably accumulated. On the export side it is again noticeable that fewer deliveries are being made to neutrals, and that Allied Powers take the bulk that is being sent away, France being the biggest customer. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.*

Iron and Steel.—The intense activity which continues to be a regular feature of Sheffield trade is reflected in the material market in no unmistakable way. Although there are now no fluctuations in the quotations, this is not wholly due to the operation of the Government scheme of prices, but more to the abnormal demand which keeps everything at the top level. Dealers have little or no trouble in disposing of the whole of their output, be it what particular kind it may, at the full maximum quotation. For the basic sorts of pig-iron there has latterly grown up a much more persistent inquiry than what existed in the earlier part of the year, but, thanks to the initiative of the Ministry of Munitions, who foresaw the need, makers have the situation well in hand, having previously, at the urgent request of the department named, set furnaces aside specially to produce this quality. Other brands of common iron are only slightly less in request than the basic. It is recorded that the authorities are well satisfied with the efforts up-to-date to expand the steel production, but that these are not yet all-sufficing is shown by the fact that there is hardly any steel available outside direct war work. The list of goods added to those available for export, and for which open-hearth or crucible steel can be used, is eloquent testimony of the great call there is for the material for work of the first national importance. There is an ever-growing demand for steel for ship-building purposes, and for other work which Sheffield is directly interested in, but which cannot in these days be specified. It is interesting to note that, though there is no maxima for acid billets, yet prices have maintained a steady figure throughout the past few months, and it is considered that there will be no drastic alteration for some time ahead. The current quotations for Siemens acid are 15*l.* 10*s.* to 18*l.* 10*s.*, the latter for very superior sorts, and for Bessemer 14*l.* to 14*l.* 10*s.* Basic billets are stated to be 11*l.* net at local works, but they are not plentiful. Nearly all the large firms have some substantial extensions on hand, and among the more striking are those for shop additions, open-hearth, crucible and electric furnace erections, rolling-mill developments, forges, and the installation of much new plant. The busy season of the agricultural engineers continues, and among the latest list of customers must be numbered new recruits to the national army on the land, with their big demands, in the aggregate, for hand implements. Overseas business, despite the multiplicity of restrictions and regulations, is good, and the latest indents are for knives, tools, saws, files, cutlery, hardware, silver-ware, electro-plate and hammers.

SHORTAGE OF IRON AND STEEL IN DENMARK.—Ever since October 1, 1916, the deliveries of iron and steel from Germany have been highly unsatisfactory. The arrivals have been so small that they only cover a very limited portion of the requirements of the Danish industry.

GAS ANALYSIS BY α RAYS.—It is known that the highest conductivity in gases can be produced by exposing them to α rays, which ionise the gas. These rays are absorbed by the gas, and if the absorption be complete the ionisation and the resulting saturation current are little affected by the nature of the gas. When the tube containing the gas is so long, however, that saturation is just secured by a heavy gas, the current would not be saturated if the gas were replaced by another less dense gas. On this peculiarity Professor F. Krüger, of Danzig, has based a new method of determining the proportion of two gases in a mixture, often a troublesome problem. The method is a current measurement, and as the currents are very weak, of the order of 10^{-9} ampere, very high resistances are required. At the winter meeting of the Bunsen Gesellschaft Krüger explained how he produced high resistances for this purpose. He volatilises platinum cathodes by the electric discharge and condenses the platinum vapour on little rods of amber; in this way he has prepared a series of film resistances ranging from 5×10 up to 3×10^{13} ohm. The analytical method is said to be expeditious and reliable within 0.1 per cent. or less.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Firmness continues to characterise Cleveland pig-iron. Supply is fairly plentiful and a good business is passing. Shipments show considerable improvement, but are still handicapped by the tonnage situation. Little or no difficulty is now experienced in obtaining export licences for France and Italy, but permits for dispatch to other countries are very sparingly granted, some, however, having been issued for shipment to Japan. Demand for Cleveland pig-iron for Italy promises to increase in consequence of stoppage of supplies from America. Home trade is on quite a satisfactory scale. With the wagon supply now sufficient to meet requirements home consumers are receiving ample and regular supplies. Allocations for May are expected to be large and such as fully to satisfy all home needs. Whilst most buyers of Cleveland pig-iron incline to confine operations to purchases for early needs, a few substantial inquiries on forward account are reported, and there are negotiations for delivery over the next six months. Thus indications of continued activity are not wanting. For home consumption No. 3 Cleveland pig, No. 4 foundry and No. 4 forge all stand at 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; whilst for shipment to our Allies No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, and No. 1, 107*s.* 6*d.*

Stocks of Pig-Iron.—The quantities of pig-iron lying at makers' yards are not known, but they cannot be heavy, and the stock of Cleveland pig-iron in the public warrant stores has been reduced to such an extent that it may disappear at almost any time, the quantity held standing at 2,117 tons, all of which except 6 tons of iron deliverable as standard is No. 3 quality.

Hematite Iron.—Sellers of East Coast hematite iron are as emphatic as ever in their claim that the situation warrants substantial advances in prices, but opinion differs as to whether a rise will be sanctioned. Marked disinclination is shown to accept orders to any extent at the rates that have ruled for some time past, and as a consequence Nos. 1, 2 and 3 are largely nominal at 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Production of Pig-Iron.—There is reason to believe that at an early date one or two blast-furnaces now making hematite iron will be transferred to the production of Cleveland pig-iron. The number of furnaces now in blast on the North-East Coast is 77, of which 34 are turning out Cleveland pig-iron, 30 are making hematite, and 13 are manufacturing special kinds of iron.

Coke.—The supply of coke is more than ample for requirements, but a continued heavy demand for local use upholds values of descriptions needed for the blast furnaces, and average sorts keep at the fixed maximum of 28*s.* at the ovens; whilst up to the limitation price of 30*s.* 6*d.* at the ovens has to be paid for low phosphorus qualities.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel are very busily employed and are still adding to their huge output. Pressure for delivery of Government work continues heavy, but notwithstanding this the production of material for mercantile shipbuilding has assumed very large proportions, and still shows gratifying growth. Prices are strong. The following are among the principal market quotations for home use:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Ironstone Miners' Wages Advanced.—At a recent conference of Cleveland ironstone mine-owners and men's representatives, held at Middlesbrough, it was agreed to advance ironstone miners' wages by 0.75 per cent. under the certified average net selling price of Cleveland pig-iron for the first quarter of the year, a claim by the men for a war bonus being adjourned. A further meeting of owners and men's representatives was held this week, at which the miners were granted a special advance of 10 per cent., the owners reserving the right to take this into consideration in discussing, three months hence, any advance that may be due to the men under the Cleveland pig-iron ascertainment for the second quarter of the year.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The improvement in the situation on the Cardiff coal market is well maintained. The heavy shipments which are taking place are restricting the quantity of free coal on the market, and in some cases where sellers of the better classes of steam coals were not affected by the Admiralty prohibitions on sales quotations reached limitation figures. The average position, however, was not quite so strong as this. Steam large coals ruled generally between 27*s.* and 28*s.*, with other descriptions higher in sympathy. For best drys 27*s.* was asked for shipment next week and up to 25*s.* 6*d.* for second classes of these coals. Western Valleys were ruling between 26*s.* 6*d.* and 27*s.*, and Eastern Valleys were firm for the best qualities up to 25*s.* 6*d.* Bituminous qualities lagged somewhat, and No. 2 through Rhonddas were obtainable at about 18*s.* In the small coal market a parcel of the best bunker descriptions was reported to have changed hands at 18*s.*, but 16*s.* 6*d.* would appear to have been a better indication of the real market position, while for cargo descriptions prices ruled nominally between 13*s.* 6*d.* and 14*s.* 6*d.* There was little change noticeable in other sections of the market, but in the sale of coke arrangements are now in force fixing prices for neutral as well as for allied destinations. For the latter the price is fixed at 47*s.* 6*d.* for foundry coke, but for neutral markets the new prices are 70*s.* for foundry and 65*s.* for furnace.

Newport.—The strength of Newport coal has been fully maintained, and the prevailing tendency is towards still higher figures. The opinion is gaining ground that the present is a favourable opportunity for insisting upon a minimum of 30*s.* for all classes of large coals shipped not merely to neutrals but also to allied destinations, and the circumstances at the moment certainly seem favourable towards this opinion materialising either through a voluntary understanding between the sellers or through external action on the part of the Coal Controller. Black Veins were quoted up to 26*s.* 6*d.* and even 27*s.*, Western Valleys between 25*s.* 6*d.* and 26*s.*, and best Eastern Valleys up to 24*s.* 6*d.* There was little change in other directions.

Dockmen for the Army.—As already reported, there has been a good deal of discussion regarding the suggestion of the local tribunal that arrangements should be made with a view of releasing men for the Army. At the meeting of the Cardiff Chamber of Commerce on Wednesday the matter was again discussed, and it was resolved to open a register for the registration of the names of principals of firms of military age who may require their businesses being looked after in the event of their being called upon to join the colours, and also as a corollary a list of members of the Chamber who would be prepared to render the assistance desired. It was pointed out that whilst all the senior members were only too ready to help the younger members under these circumstances, the difficulty was that there had been such a depletion of staffs that several would be unable to give that assistance which was deemed necessary. It was, however, stated that there were some of the members in such a position that they would be able to spare the time requisite for the carrying on of the business of those young dockmen who would have to respond to their country's call.

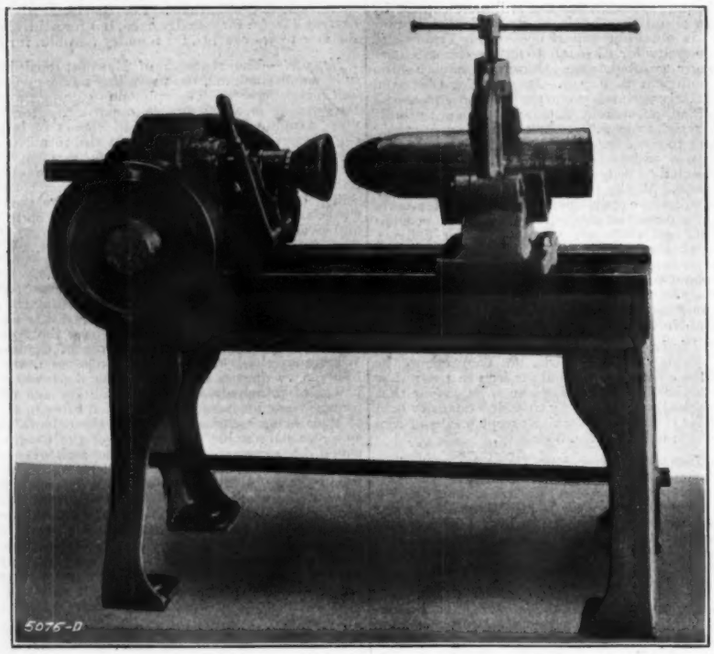
Coal Prices for the Allies.—In local coal trade circles the view is now generally entertained that the time has arrived for such a revision of the maximum coal prices for France and Italy as will remove the anomalies which have now existed for many months past and prevent the sale of coal under limitation prices. It is pointed out that when the scheme was originally formed it was intended that France and Italy should be guaranteed supplies under conditions which would protect them against the violent fluctuations which had previously taken place in the market for coals for export. The coalowners readily agreed to a maximum of 30*s.*, because they felt that on the then basis of the cost of production that was a reasonable figure, although it involved a sacrifice, when agreed to, of anything from 10*s.* to 15*s.* per ton. During the past twelve months, however, conditions have altered enormously, and that to the disadvantage of collieries, for not only has the cost of production increased by many shillings per ton, but the market price of large coal has fallen to about 25*s.* It is hoped that under the new financial conditions the Coal Controller will fix such a price for allied, as well as for neutral, ports as is fully warranted by the prevailing conditions.

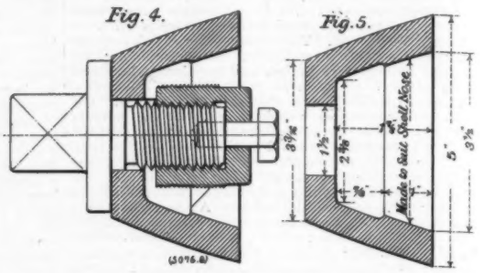
DIRECTORY OF PAPER MAKERS.—This directory of paper makers in the United Kingdom is issued at the price of 1*s.* net (post free, 1*s.* 5*d.* in the United Kingdom and 1*s.* 8*d.* abroad) by Messrs. Marchant, Singer and Co., 47, St. Mary Axe, E.C. It contains over 230 pages, giving the names of paper makers, &c., of the United Kingdom under various headings; a list of trade designations, water-marks, trade names, and a chapter on the paper trade customs and sizes of paper.

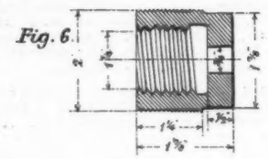
BRITISH-ROUMANIAN CHAMBER OF COMMERCE IN LONDON.—At a meeting of British and Roumanian firms interested, held at the London Chamber of Commerce on the 2nd inst., says *The Board of Trade Journal*, it was decided to form a British-Roumanian Chamber of Commerce, having for its object the promotion of trade between the United Kingdom and Roumania. His Excellency the Roumanian Minister in London was elected president of the Chamber, and the Earl of Bessborough (chairman of the Bank of Roumania, Ltd.) and Sir Albert K. Rollit (Consul-General for Roumania) were elected vice-presidents. An executive was appointed to settle the memorandum and articles of association and bye-laws. Mr. H. Locke (London manager of the Bank of Roumania, Ltd.) was elected hon. treasurer, and Mr. C. E. Musgrave (secretary of the London Chamber of Commerce) hon. secretary of the new body. The formation of the Chamber is the outcome of an expressed desire on the part of those connected with Roumanian trade that some active steps should be taken to embrace the opportunity which will present itself after the war of considerably extending the United Kingdom's trade with Roumania, having regard to the fact that signs are not wanting that Roumania is not prepared to extend to her present enemies the trade welcome they enjoyed before the war. The British-Roumanian Chamber of Commerce will be solely devoted to British-Roumanian interests.

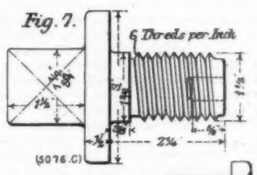
SHELL NOSE TIGHTENING MACHINE.

CONSTRUCTED BY MR. GEORGE PORTEOUS, ENGINEER, LEEDS.









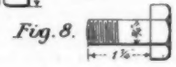
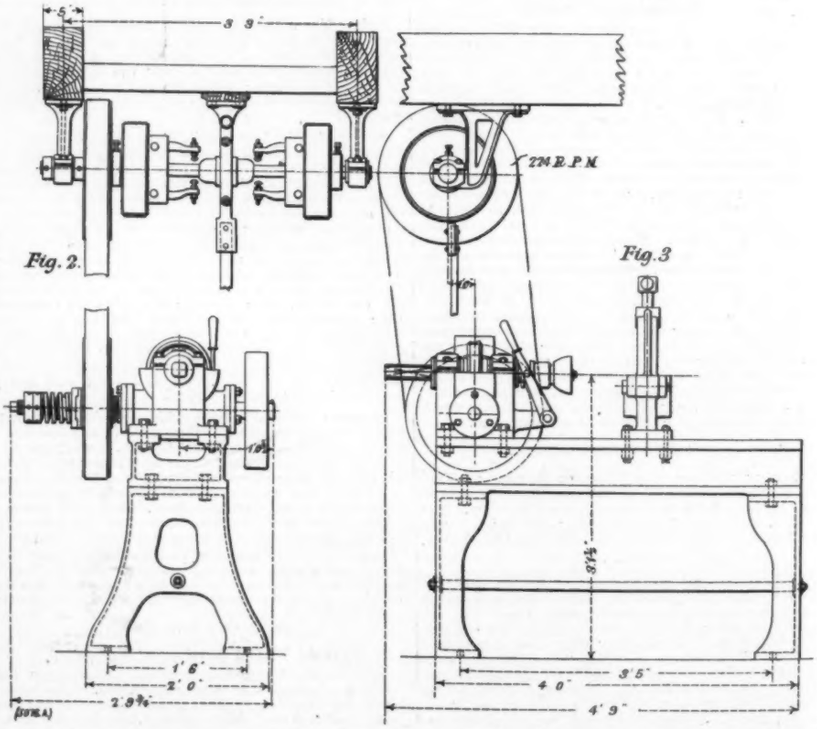


FIG. 1.

We illustrate on this page, by perspective view and detailed drawings, a simple yet effective machine, largely in use, for tightening the noses of shells, as manufactured by Mr. George Porteous, of Leeds Bridge Works, Leeds. As shown in Fig. 1, it follows the lines of a simple lathe, the headstock spindle being driven (Figs. 2 and 3) by worm and worm wheel mounted on a cross-shaft, on one end of which is the flywheel and on the other the pulley, secured by a clutch with spring-pressed dog teeth to admit of slip should the speed exceed the predetermined rate. The countershaft belt pulley is arranged to drive in either direction. The shell, it will be seen, is secured in a holder (which may be arranged to accommodate any size of shell) which slides on the ordinary lathe type of bed, so that it is applicable to any length of shell. The interesting feature is the method of securing the adapter for tightening the shell nose. This is shown in its assembled form in Fig. 4, the constituent units being illustrated in Figs. 5 to 8. The adapter is formed with a nose plug of cast steel (Fig. 6), with an external thread 14 per in. and 2 in. diameter, and an internal thread of 6 per in. Fig. 7 is a cast steel square head screw thread, cut to suit the internal thread of the plug, Fig. 5 is a mild steel clamp to grip the shell nose, and Fig. 8 a ¾-in. diametrical hexagon steel screw. The operation of tightening the shell nose is as follows:—The adapter is first screwed into the shell nose, which is then entered into the shell body, the square socket of the spindle being brought up to the square shank. The machine is then set in motion, and as the shell becomes tighter the nose plug revolves until the clamp grips the shell nose. When this is tightened home the clutch on the machine automatically cuts the power off. In order to release the adapter the countershaft is reversed, the screw (Fig. 7) with coarse threads unscrews in the plug (Fig. 6) up to the shoulder of the set screw, which in turn unscrews. Thus in the distance between the shoulder of the set screw and the face of the plug the clamp is slack, and the whole arrangement can be unscrewed by hand.

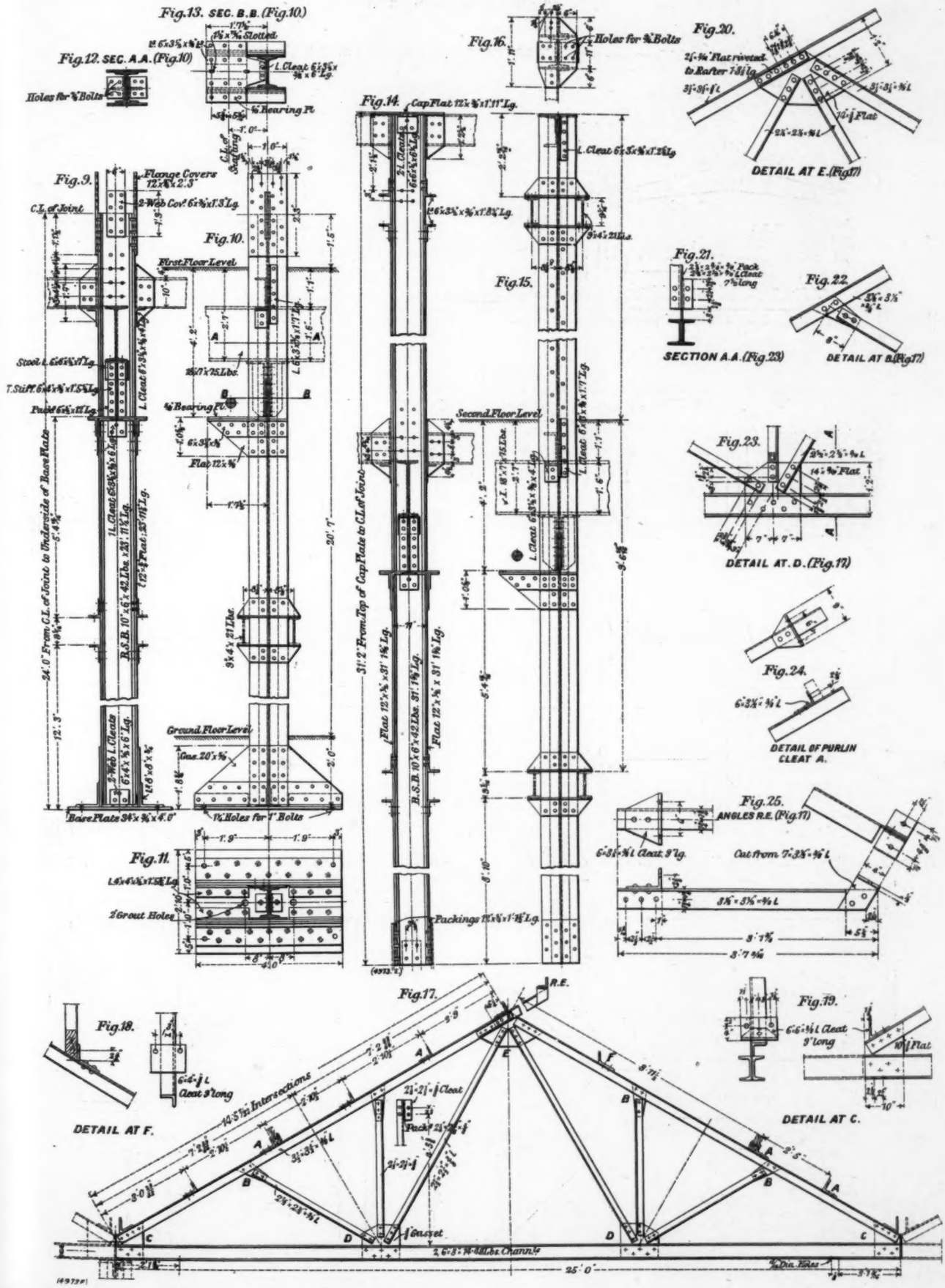


ADMIRALTY COSTING DEPARTMENT.—The Board of Admiralty have appointed Mr. A. F. Whinney, senior partner of Messrs. Whinney, Smith and Whinney, of London, their adviser upon costs of production, and he will be in direct charge of a costing department attached to the department of the Director of Navy Contracts.

THE STANDARDISATION OF ENGINEERING MATERIALS.—On Wednesday next, May 2, the "James Forrest" lecture for the present year will be delivered at the Institution of Civil Engineers by Sir John Wolfe Barry, who has taken as his subject "The Standardisation of Engineering Materials and its Influence on the Prosperity of the Country." The subject is one of great importance at the present time, and Sir John's views upon it are certain to be worthy of most careful attention. It is now 16 years since the Engineering Standards Committee was established, and during that period it has carried out an enormous amount of most useful work and has exercised a powerful influence on engineering practice. Starting on a comparatively small scale, its growth has been both rapid and continuous, and probably few except those intimately connected with its organisation appreciate the widespread character of its operations. As chairman of the Main Committee, and as the initiator of the movement which led to the foundation of the committee, Sir John Wolfe Barry is especially fitted to deal with the subject of his lecture, and we have no doubt that he will not only place before his hearers an interesting account of the work already accomplished, but will also deal fully with the very important developments now in progress with a view of promoting the increase of our foreign trade. Already steps have been taken to translate the British Standard Specifications into French, Spanish and Russian, and to provide for publication of both the British and foreign editions at a very low cost, and the work is being pushed forward energetically.

A NEW VICKERS MACHINE GUN SHOP.

(For Description, see Page 392.)



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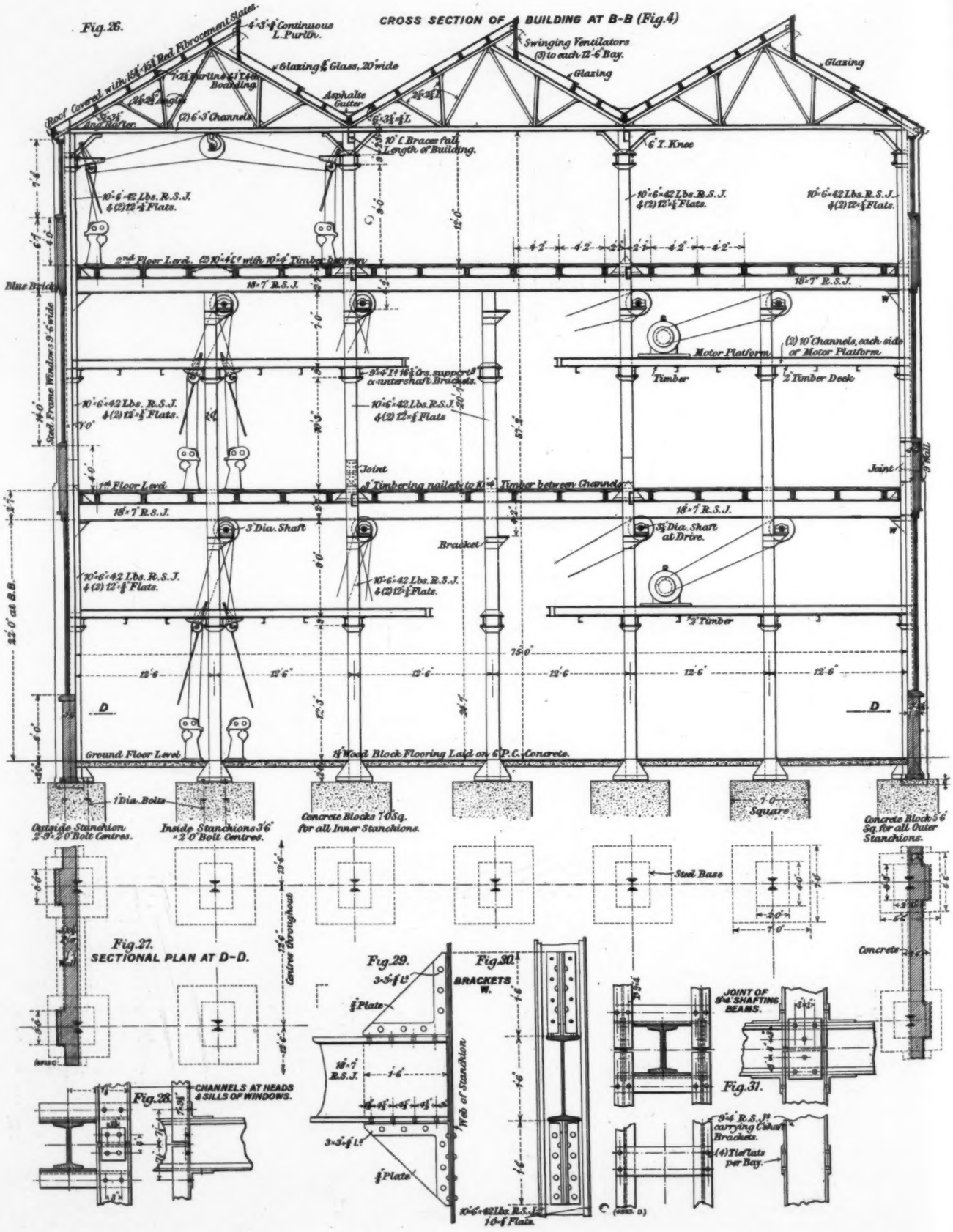

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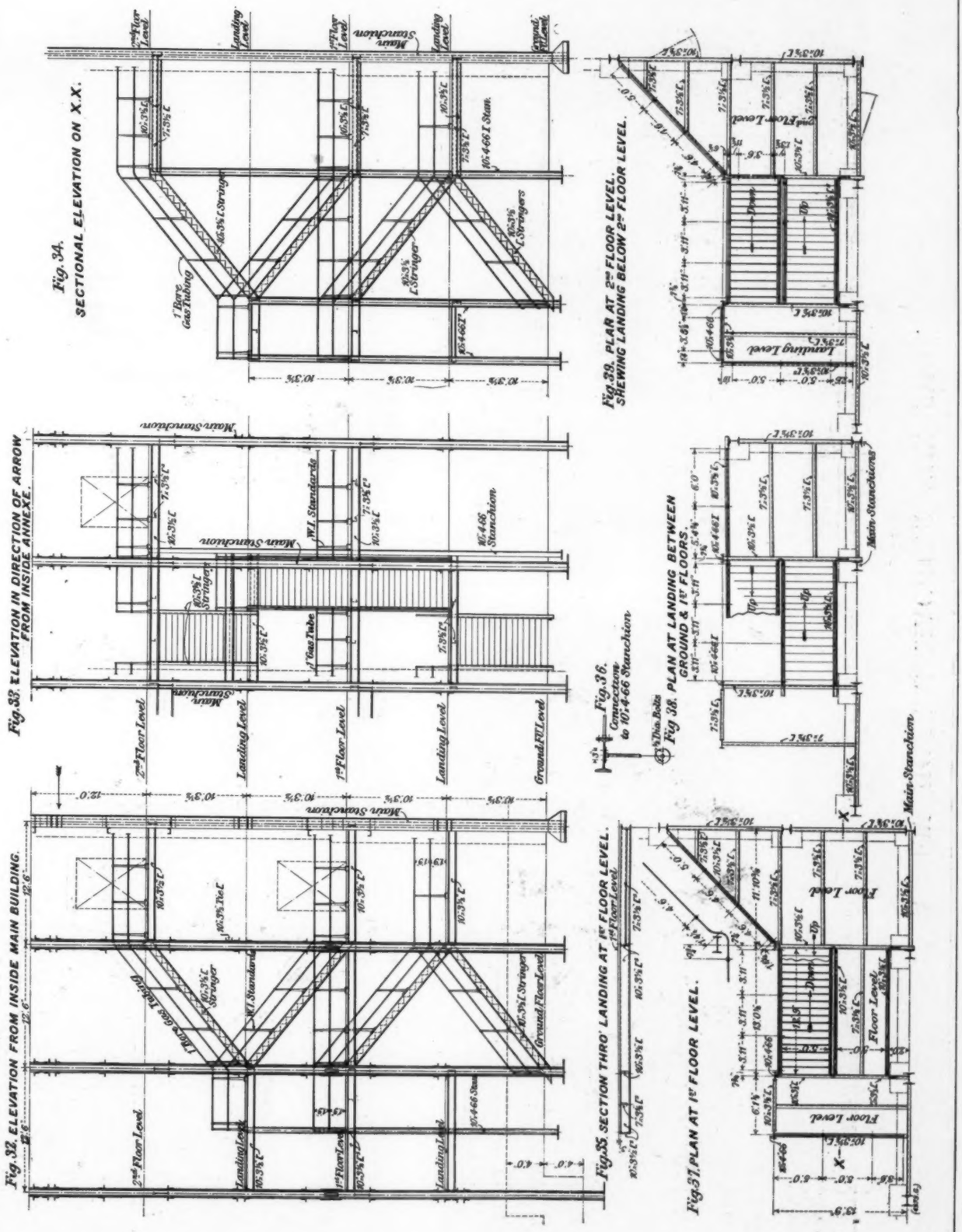
Fig. 34. SECTIONAL ELEVATION ON X.X.
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Fig. 33. ELEVATION IN DIRECTION OF ARROW FROM INSIDE ANNEXE.
Fig. 36. Connection to 10'4·66 Stanchion.
Fig 38. PLAN AT LANDING BETWEEN GROUND & 1st FLOORS.
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Fig. 35. SECTION THRO' LANDING AT 1st FLOOR LEVEL.
Fig. 37. PLAN AT 1st FLOOR LEVEL.
Main Stanchion
2nd Floor Level
Landing Level
1st Floor Level
Ground Floor Level

A NEW VICKERS MACHINE GUN SHOP.

(*For Description, see Page* 392.)

FIG. 40. THE BUILDING, DECEMBER 10.

FIG. 41. THE TOOL ROOM, OCTOBER 30.

FIG. 42. THE TOOL ROOM, DECEMBER 31.

FIG. 43. AUTOMATIC MILLING SECTION, DECEMBER 31.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—8663 and 8526 GERRARD.

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With Four One-Page Plates of a NEW VICKERS MACHINE GUN SHOP.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, April 27, at 5 p.m., at the Imperial College of Science, Exhibition Road South Kensington, S.W. Agenda:—(1) "A Note on the General Equation for Wave Motion in an Elastic Medium," by Professor J. A. Fleming, M.A., D.Sc., F.R.S. (2) "The Effect of Stretching on the Thermal Conductivity of Wires," by Mr. A. Johnstone, B.Sc. (3) "Cohesion," by Professor H. Chatley, B.Sc.

THE ROYAL SOCIETY OF ARTS.—Monday, April 30, at 4.30 p.m. Howard Lectures.—"The National Shortage of Iron Ore Supplies," by Professor W. G. Fearnsides, M.A., F.G.S., University of Sheffield. Lecture I: "Available Home Supplies of Ore." Wednesday, May 2, at 4.30 p.m. Ordinary meeting.—"Herb-Growing in the British Empire: its Past, Present and Future," by Mr. James Chapman Shenstone, F.L.S., M.P.S

THE RÖNTGEN SOCIETY.—Tuesday, May 1, at 8.15 p.m., at the Cancer Hospital (Free), Fulham Road, S.W. Discussion on "The Future of the British X-Ray Industry" will be continued by the President, Captain Thurstan Holland, M.R.C.S.

THE FARADAY SOCIETY.—Tuesday, May 1, at 8 p.m., in the rooms of the Chemical Society, Burlington House, Piccadilly, W., a General Discussion on "Osmotic Pressure," to be opened by Professor Alfred W. Porter, F.R.S. Dr. F. Tinker will read a paper on "The Colloidal Membrane: its Properties and its Function in the Osmotic System." Mr. W. R. Bousfield, F.R.S., will read a paper on "Osmotic Pressure in Relation to the Constitution of Water and the Hydrates of the Solute."

THE INSTITUTION OF CIVIL ENGINEERS.—Wednesday, May 2, at 5.30 p.m. Special meeting. The Twenty-Fifth "James Forrest" Lecture, "The Standardisation of Engineering Materials and its Influence on the Prosperity of the Country," will be delivered by Sir John Wolfe Barry, K.C.B., LL.D., F.R.S., Past-President Inst.C.E., Chairman of the Engineering Standards Committee. Members of the Institutions of Mechanical Engineers, Naval Architects, and Electrical Engineers, and of the Iron and Steel Institute are invited to attend the lecture.

THE IRON AND STEEL INSTITUTE.—Thursday, May 3, at 10.30 a.m., at the Institution of Civil Engineers, Great George Street, Westminster. The Council will present their report for the year 1916. The hon. treasurer will present the statement of accounts for 1916. Scrutineers will be appointed for the examination of voting papers for election of new members and associates of the Institute. The President will move the adoption of the proposed new by-law for the expulsion of members, as amended as the autumn meeting, for incorporation in the by-laws of the Institute. Award of the Bessemer Medal for 1917 to Mr. Andrew Lamberton, Vice-President. A selection of papers will be read and discussed. (Nos. 1, 3, 8.) Friday, May 4, at 10 a.m. The award of grants from the Andrew Carnegie Research Fund in aid of research work will be announced. Papers Nos. 2, 4, 6 will be read and discussed. (1) Mr. Cosmo Johns, F.G.S., Sheffield, "Note on the Properties of the Refractory Materials used in the Iron and Steel Industries." (2) Mr. L. Grenet, Firminy, France, "The Penetration of the Hardening Effect in Chromium and Copper Steels." (3) Mr. J. N. Kilby, Sheffield, "Steel Ingot Defects." (4) Mr. F. C. Langenberg, Harvard, U.S.A., "Cementation by Gas under Pressure." (5) Mr. G. P. Rakdabaugh, Sparrow's Point, U.S.A., "Origin and Development of the Railway Rail." (Being an historical note communicated by the courtesy of the Ebbw Vale Company.) (6) Mr. N. Tschischewsky, Tomsk, Russia, "Case-Hardening of Iron by Boron." (7) Mr. N. Tschischewsky and Mr. N. Schulgin, Tomsk, Russia, "Determination of the Line SE in the Iron-Carbon Diagram by Etching Sections at High Temperatures in Vacuo." (8) Mr. F. C. Thompson, Sheffield, "Influence of Surface Tension on the Properties of Metals, especially of Iron and Steel."

THE INSTITUTE OF METALS.—Thursday, May 3, at 8.30 p.m., at the Institution of Civil Engineers, Westminster. May lecture by Professor W. E. Dalby, F.R.S., on "Researches made possible by the Autographic Load-Extension Optical Indicator."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 4, at 5.30 p.m. A discourse will be delivered by Mr. H. Wickham Steed. The subject is "Some Guarantees of Liberty." Afternoon lectures next week at 3 p.m. Tuesday, May 1. Professor C. S. Sherrington, M.D., LL.D., F.R.S., Fullerian Professor of Physiology, Royal Institution, on "Tetanus: its Prevention, Symptoms and Treatment" (Lecture I). Thursday, May 3. Professor Gilbert Murray, M.A., LL.D., Litt.D., Regius Professor of Greek, University of Oxford, on "Pagan Religion at the Time of the Coming of Christianity—Misleading Preconceptions—the Raw Material—Dea Roma" (Lecture I). Saturday, May 5. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., Professor of Natural Philosophy, Royal Institution, on "The Electrical Properties of Gases" (Lecture I).

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, APRIL 27, 1917.

INDUSTRIAL PEACE AND INDUSTRIAL PROSPERITY.

LOOKING back over a long experience of the meetings of technical societies we cannot remember any such expression of enthusiasm as that which followed the reading of Mr. Michael Longridge's presidential address before the Institution of Mechanical Engineers last Friday evening. The applause burst forth instantly and rolled on—and on, and on—for minutes, as if the audience felt that the conventional clapping was quite inadequate to express their feelings, and yet they could find no other means. Mr. Longridge's eloquent peroration had momentarily lifted his hearers out of the pettiness and meanness of daily life, and had bid them realise the splendid opportunity which lay before them and around them of inaugurating a greater peace than that with our enemies, a peace between science and practice and between master and man. He spoke to them not as engineers only, but as parts of a great human community who were vitally interested in the happiness and prosperity of their fellows, and who were the heirs of a long period of selfish and autocratic action on the part of employers and ignorant and vengeful resistance on the part of the men. The president spoke optimistically of the future, and expressed his belief in a power immanent in the cosmos to evolve order out of confusion. He said: "I believe there is a power that works unceasingly through right and wrong to weave the tangled web of anarchy into the pattern of an ordered life, and that these ephemeral troubles are but the means that it employs to lead both sides to a right conception of their duties to each other. That this enlightenment will come is sure. The ignorance of men, their prejudices and their greed, alone postpone its advent. . . . If we could lead them [masters and men], side by side in mutual trust, to bury strife, suspicion and illwill deep in the graves of their sons and brothers who have fallen in the war, and teach them to see the right as clearly as their dead sons and brothers see it now, the ideal of industrial life would be in sight." It was well he ended on this splendid note of hope, for he had laid a terrible indictment against the employers in this country, and had not spared the workmen. But this was not done by way of railing accusation, or as a pessimistic outburst. It was rather a scientific diagnosis of the causes of the ills from which we have suffered and are suffering, showing how want of thought and sympathy hardened into selfishness, how selfishness begot greed, how greed acting upon ignorance generated violence, and violence led to repression. The whole vicious circle was dissected and exposed, and made the foundation of a plea for patience and forbearance.

In the long struggle between capital and labour there have been deep wounds inflicted on both sides, and it will be years before they will cease to ache and tingle. Sometimes victory has inclined to one side and sometimes to the other, but uniformly there have been heavy casualties, and the price of a patched-up peace has had to be paid by both combatants, often with little to show for it. Although immense progress has been made in arbitration and conciliation, yet the parties never come to the discussion with judicial minds. On both sides there is the memory of broken engagements, of evaded responsibilities, and of veiled opposition to the carrying out of agreements. It is a forlorn Peace, with bedraggled wings and halting steps, which announces to the world the result of the conference. It is to be feared that this state of affairs will continue unless both parties can agree to let bygones be bygones as far as possible, except to remember them as an excuse for the failings of their opponents and as a reason for sympathy and patience. The best means of attaining this condition of affairs is to listen to the recital of our own faults by a candid friend—"a fellow feeling makes us wondrous kind." Last Friday many employers must have been shocked and surprised to hear the serious sins attributable to their class, and when the address is read in our columns (see page 411) by working men they will realise that all the shortcomings are not on one side by any means.

All this has been said before, but not, so far as we remember, from the presidential chair. Other occupants may have been as clear-sighted and as intrepid as Mr. Longridge, but they have lacked his opportunity. Such utterances from them would have been only pious aspirations, and would have fallen flat on an incredulous world, even if they had not provoked antagonism. But to-day we are living on the threshold of new heavens and a new

(To face page 395).

earth, and the Utopian dreams of the past are now possibilities, if not probabilities. Across the graves of our dead sons and brothers we see matters in a new light, and realise that their blood has been largely wasted if it only serves to crush Prussian hate while leaving class hatred as active as ever at home. In the trenches it has no existence. There is mutual respect and goodwill between officers and men, with constant emulation in brave deeds and acts of kindness. In the ghastly realities of war petty advantages and mean suspicions are seen in their true value, and are freely cast away as encumbrances in the great struggle towards victory. It would be grand if we could all undergo this experience and realise that brotherhood of man which never shines so brightly as on the battlefield. That is impossible, but there is a feeling abroad that some approximation to it could and should be attained, and that in the first instance it should find expression in better relations on both sides between master and man. The applause which followed Mr. Longridge's address shows how wise he was to avail himself of the opportunity to urge upon engineers the need of bringing a new spirit to bear upon the industrial problems which await them in the near future. Appeals to the higher and spiritual side of man are sure, if well timed, of an emotional response, but there the effect generally ends, for it is often impossible to translate aspirations into deeds. The world is governed by economic laws, hence the saying: "Half the time of the wise people is spent undoing the evil wrought by the good people." Nature takes no heed of motives and never admits extenuating circumstances; it can only be ruled by those who obey it, and in industrial matters there has been a great defiance of the laws of economics.

Sympathy, goodwill and sentiment, invaluable as they are, can never solve our present industrial difficulties unless guided by knowledge. Labour wants more wages, and we all sympathise with the desire. Capital will not be content with less interest, and may reasonably ask for still greater returns. Under existing conditions neither gets what it wants, and disappointment breeds discontent. Either labour must produce more or capital must manage better; if both concur in getting the best possible output, then there is the prospect of the reasonable desires of both being gratified. Mr. Longridge devoted a considerable part of his address to indicating the weak points in our present system. He related the history of the engine-building trade of Lancashire. Once its supremacy was beyond dispute; now its sad condition is known to all. The reason is clear. Those in authority in shops and offices despised scientific knowledge, and were content to stand on the ancient ways. They paid no regard to elegance of form, took no trouble about completeness of finish, and spent no care on the arrangement of details. They did not even know the degree of economy that their engines would give, and hence they were ousted in a few years by their Continental competitors. Insufficient technical knowledge and lack of trade organisation were the causes of their decline, as they have been the causes of decline in other trades. The remedy is more knowledge and greater effort. All classes of engineers must be better educated, and, what is more important, must be suitably educated. The idea of free university education for the million, said Mr. Longridge, is most pernicious nonsense, and we entirely agree with him. The machine minder needs enough education to enable him to take advantage of any opportunities that may come to him, and, if they do not come, to extend his range of interest in his leisure hours beyond football and beer. The mechanic, the foreman, the designer, the manager and the business head have all different requirements, and as far as is feasible should have different trainings, although the choice of a curriculum is always complicated by the uncertainty of what the future has in store for the candidate. One point is clear, however, namely, that a little knowledge thoroughly grasped is far more useful than a superficial acquaintance with high-sounding subjects. Hence it is better in engineering examinations to demand a high percentage of marks in fairly elementary subjects than to accept a low percentage in advanced subjects. David with a sling and a stone was a more formidable antagonist to Goliath than he would have been if he had accepted Saul's advice to go into the conflict in shining armour.

We have not space to follow Mr. Longridge in his suggestions as to the organising of engineering manufacture. His views both on that subject and on education will repay perusal, but they may all be summed up in the demand for greater mental effort and for a "divine discontent" with our present attainments. We live in a world which changes faster and faster every day, and we are confronted by nations who have a greater faculty of adaptability than we have. We can only meet them by the constant exercise of intellectual effort, by welcoming the aid of science, by devising new methods and scrapping old ones, and, finally, by abating our ignorant and shortsighted individualism, which leaves us a crowd of units opposed to the disciplined battalions of our competitors. We are making some efforts to secure more conjoint action in the future, but the necessity for it is not yet appreciated as it should be. The great combines of Germany and America cannot be met in the neutral market of the world by the peddling methods of the past, and it will be a humiliating experience for us to see the opportunities won by the valour of our sons lost by the ineptitude of their fathers. From whatever point of view we regard the future—industrial, educational, manufacturing or commercial—the problem is seen to be intellectual. We want more thought brought to bear on our affairs, more imagination to enable us to realise our future, more sympathy in dealing with our fellow men, more organisation in our workshops, and greater effort in commerce. We have never been an idle nation, but we have been intellectually sluggish. We have been ready to "wait and see," when we ought to have acted. We have gone into great enterprises with totally inadequate means because we have not troubled to think them out. All this must be altered in the future, and it is well the fact should be proclaimed to engineers from a presidential chair.

HIGH-SPEED TELEGRAPHY.

IT may sound surprising that—speaking of pre-war conditions—there has not been any urgent demand in this country of late for high-speed telegraph apparatus, because the volume of telegraph traffic had not in recent years shown any material growth. The statement must not be misinterpreted into meaning that the problem had been neglected in this country. Many improvements and systems have, indeed, been worked out and tried over here, together with many innovations from abroad, especially from America, where the telegraph service is in the hands of competing companies. In broad terms, the choice lies between two classes of systems: the automatic and the multiplex. After studying and, so far as possible at present, thoroughly testing many systems and instruments, the Committee appointed by the Postmaster-General to consider the question of high-speed telegraphy favours in its report—which we will denote by report in what follows—the multiplex system. The two lectures delivered in March by Professor J. A. Fleming, F.R.S. —he will pardon us if we add at telegraph speed—in the Royal Institution will assist us in considering the problem.

High-speed apparatus are designed to increase the output of a wire, for the line generally remains, even with modern expensive instruments, the most costly part of the plant. The fundamental simplex working, with one operator at each end both to send and to receive, has largely been superseded. Almost all actual systems admit of duplex working with two operators (or two sets of operators) at each end, one sending and one receiving simultaneously. A duplex Morse circuit has a total carrying capacity of $2 \times 30 = 60$ words per minute. When the system admits of substantially greater output it is called a high-speed system, and two main classes of these may be distinguished. The automatic system provides an actual higher speed of working with a limit of two channels in opposite directions. The multiplex system distributes the higher speed of the circuit among three or more operators. Of the first class the Wheatstone, an automatic Morse, is the typical instrument; of the second class the quadruplex, consisting of two duplex circuits on one wire, is typical. Improvements of the old Morse telegraph, which in its proper place retains its utility, have been effected in many ways. The codes or signals may be simplified; the work of the operators at either end may be facilitated, the time intervals between the signals, during which the line is idle, may be utilised, and each system may combine various improvements and be adapted to average regular traffic or to periodically heavy traffic, to serve large towns or scattered villages, business houses or clubs, so that a very large variety of systems has been worked out. The variety is required; to use one system to the exclusion of others would be quite unprofitable. The developments, moreover, have so often been on similar lines and the modifications so numerous, that it is no longer possible to characterise every system by a particular name.

In the Morse code the dash is equivalent to three dot-units, and the average signal consists of eight units. In the Squier–Crehore system, designed for cable service, sine waves are sent along the wire and Morse signals are produced by suppressing the alternations as required. The various five-unit codes make use of permutations of positive and negative pulses, always five in number and all of the same duration, and this constant value of a unit has substantial advantages. On the other hand, the Morse signals are readable or audible anywhere, whilst the five-unit signals are meaningless without a printing mechanism with appropriate means of selection to translate them into type letters. Yet owing to the wide adoption of instruments depending upon units of equal lengths the Baudot five-unit code appears likely to prevail. The current reversals are produced by means of polarised relays which respond only to the reversal, not to the starting and the stopping of the current.

The name "automatic" came up when the sending, so far by hand with the aid of a key, was produced by a perforated tape or slip into which the signals had previously been punched by the aid of machinery. At first the operator had really to punch the separate dots and dashes. Then typewriting machinery was introduced. The report speaks highly of the Gell keyboard perforator; the Gell transmission method of Wheatstone working, which connects two or more transmitters direct to line in turn, has only been tried so far. The American Kleinschmidt perforator, mentioned as equally satisfactory and, moreover, cheap, has been taken up by Messrs. Creed, Bille and Co., whose receivers are recommended as most useful for press work; in the Creed perforator a polarised relay works a pneumatic relay and this a pneumatic engine. The report also mentions the Siemens and Halske automatic printing telegraph, in use between London and Liverpool, which comprises keyboard and receiving perforators acting directly, without interposition of a perforated slip; each perforating keyboard becomes a re-perforator by the insertion of a loose-cord plug; against this system is the use of a special five-unit code. The general arrangement for duplexing, which also serves for telephone purposes, is that of a split Wheatstone bridge, the two halves of which are connected, on the one side by the line wire, and on the other by an artificial line consisting of an adjustable resistance at each end and the earth.

Nearly all actual multiplex instruments are based upon the system of Baudot, which grew out of the Hughes typewriter and other known devices which A. Baudot, more than thirty years ago, combined into an ingenious system of great utility. The rotating arm in connection with the line passing over the depressed keys of a board of 28 keys and a synchronising device were already parts of the Hughes typewriter which found much more favour on the Continent than in England. The phonic wheel is connected with the names of Paul la Cour, Delany and others. The synchronising device which maintains correspondence of speed between the distributors at the two ends of the line is both the distinguishing feature and the vulnerable point of multiplex systems. Baudot secures synchronism by means of a centrifugal friction governor,

a mechanical correction and a special correcting signal; in the Western Electric Company multiplex the special signal is dispensed with, and the message signals themselves correct the phase. The distributing arms, which pass over sets of six constants, *e.g.*, four arms for four sets, may go round twenty times a second. Each arm is worked at about thirty words a minute, and by observing the cadence or rhythm of the system the operator knows when the distributor gives him the use of the line. Five of the contacts or keys are required for the five units of the Baudot code. The currents are picked up by the five receiving electro-magnets whose peculiar armatures drop into nicks of a wheel, but do not allow the wheel to turn and to print a letter until all the five have operated. It is, as Professor Fleming explained it, somewhat as in the case of the key of a safe, which does not allow the bolt to move until all the levers have been raised in due sequence. With regard to the correcting signal, Professor Fleming suggested that one might imagine two motor cars, almost equal in speed, joined by a rope in such a way that when the front motor went too fast its brake was put on by the rear motor; in the Baudot system the receiving distributor was slightly faster than the other. In England, Baudot apparatus are worked on underground lines on quadruple, quintuple and sextuple (six arms) circuits, and at least eight channels with 30 words a channel (or operator) can be worked on the duplex principle on a single line or loop.

Mr. Donald Murray, inventor also of high-speed automatic apparatus and others, has modified the Baudot apparatus, replacing the Baudot governor by a reed and adopting a free-running keyboard perforator, with very promising results; on a wire London–Manchester his system has been worked double duplex for four years, and the synchroniser has quite recently been further improved.

For busy lines the report considers the Western Electric multiplex apparatus the most generally satisfactory. It is described as an American development of the Murray system. A quadruple duplex installation has been working since March, 1916, between London and Manchester, the apparatus dealing with two-thirds of the whole traffic on a single circuit at the rate of 40 telegrams, sometimes 49, per hour per operator. Not many circuits in the kingdom would keep such apparatus fully fed, but "forked" circuits linking several towns should be made up, the report recommends, to give greater scope to the system. It works with a free keyboard perforator and a cross-perforated sending tape on the five-unit code and prints directly on the "page" of a continuous roll of paper, which is cut off after each message. Some other apparatus of the Western Electric are also recommended. Without wishing to adopt page or column printing to the exclusion of tape-printing, the committee advises that the extension of systematic Wheatstone working should be discontinued in favour of multiplex systems, because they conduce to economy in staff and office equipment and are subject to fewer serious stoppages and necessitate less spare plant and less costly maintenance, in spite of the difficulties of synchronising.

The report does not particularly refer to submarine telegraphy, with regard to which Professor Fleming ascribed the chief modern progress to improvements in the sensitiveness of syphon recorders, cable relays and repeaters. The syphon recorders of Mr. Tinsley and the remarkable relays of Sydney Brown have been mentioned by us on other occasions. In the Heurtly magnifying relay two platinum wires are heated by a local current and cooled by a jet of air, the line current moving the wires in and out of the jet, so that the balance of the bridge, of which the wires form part, is more powerfully upset than it would be by the feeble line currents. Axel Orling's jet relay embodies the same idea. A jet of acidulated water is deflected by the receiving coil and impinges on an inclined plane carrying a number of fine glass tubes; the resistance of this circuit is thereby varied, and the fluctuations actuate the local recorder. We can only add that Professor Fleming gave, in his second lecture, a rapid but excellent review of advance in telephony and radio-telephony, dwelling on wave distortion in cables, loaded cables (Pupin and Krarup systems) and their analogues in loaded vibrating cords—which he explained by his beautiful models—automatic telephone exchanges, and finally the audion receiver, a Fleming glow-lamp valve-rectifier, in which a grid is interposed between the lamp filament and the metal cylinder; this receiver can also be utilised as an alternate-current generator. The lectures well illustrated the ingenuity of modern telegraph and telephone apparatus.

BRITISH MAGNETOS.

WHEN we consider the immense importance of aeroplanes, motor vehicles and other machinery driven by internal combustion engines, from a military, as well as from an industrial, standpoint, it is distinctly humiliating to think that just prior to the outbreak of war we were almost entirely dependent upon a German production for the satisfactory working of this class of machinery. We are referring, of course, to the Bosch high-tension magnetos, which may be said, without any very great deviation from the truth, to have been the only type of ignition apparatus in use in this country at the commencement of the war. One or two British firms had certainly commenced to manufacture these vitally important accessories, but their production was negligibly small—a fact which is not surprising when the conditions existing at the time are borne in mind. The conditions, however, were profoundly modified by the outbreak of war, which created an enormously increased demand and simultaneously cut off the supply of German machines, and since that time a British magneto industry has been established on a sufficiently firm basis to enable it, we think, to maintain itself under normal conditions, provided that it receives a reasonable amount of encouragement from the Government and the public. What British manufacturers have done in the last two or three years may be gathered from the fact that 15 firms are now engaged in the manufacture of high-tension magnetos, and that 10 of them, constituting the British Ignition Apparatus Association, have supplied some 200,000 magnetos to the Government for war purposes, chiefly for use on aeroplanes. That these magnetos are at least equal in quality to those produced in Germany before the war may safely be inferred from the recent splendid performances of our aircraft, but in the opinion of Mr. A. P. Young the developments now taking place in the design and construction of magnetos are likely, in the near future, to render British magnetos vastly superior to those of German manufacture. This opinion was expressed by Mr. Young in an interesting and instructive paper recently read by him before the Aeronautical Society, and it is to this paper, which constitutes a valuable addition to the somewhat meagre literature on the subject, that we are indebted for most of the matter in the present article.

It is interesting to note in passing that, as is the case with many other inventions developed in Germany, electric ignition did not originate in that country. All systems are, of course, the outcome of Faraday's classical experiments on magneto-electric induction, but the first application of electric ignition to internal combustion engines was due to Lénoir, who, in 1860, utilised the spark from an induction coil, in conjunction with a high-tension distributor, in almost exactly the same manner as is now extensively employed in the United States. Lénoir also used sparking plugs having all the essential features of a modern plug. The first magneto for ignition purposes, which appears to have been constructed by Marcus, was of the low-tension type, the current produced in a rotating H armature being made and broken by moving contacts inside the engine cylinder. In 1898 Simms and Bosch produced a low-tension magneto of the stationary-armature type and, subsequently, by the addition of a secondary winding on the same armature, a high-tension magneto was evolved. Here, again, the original idea for a high-tension magneto appears to have been due to a Frenchman, M. Boudeville, but the omission of a condenser connected in parallel with the contact breaker was a fatal bar to the success of his system. The credit for the commercial production of a satisfactory high-tension magneto must, however, be given to the Bosch Company, of Stuttgart.

The essential parts of any high-tension magneto include a magnet system, an armature provided with primary and secondary windings, a contact breaker (with condenser) to interrupt the primary circuit, and a distributor to connect the secondary circuit with each of the sparking plugs in turn. The changes in the direction of the flux through the armature are generally produced by the rotation of the armature itself, but similar results are often obtained by means of an inductor composed of iron segments made in the form of a sleeve which revolves around a stationary armature. In another type of magneto iron masses are rotated in proximity to an external armature core, and machines of the three types mentioned may conveniently be designated rotating-armature, sleeve-inductor and polar-inductor magnetos, respectively. In all types the cycle of operations is similar. The rapid reversals of flux in the armature core induce an alternating E.M.F. in both primary and secondary windings. The contact breaker, which is operated by a cam, is arranged so that the primary circuit is closed while the induced E.M.F. is increasing from zero to its maximum value and for some little time after the maximum voltage is passed—in fact, until the current in the primary resulting from the induced E.M.F. is at, or near, its maximum value. When this point is reached the contact breaker is suddenly opened by the cam, and, since sparking at the contacts is prevented by the condenser, the primary current is broken very rapidly. This causes an almost instantaneous collapse of the magnetic field associated with the primary current, and, as this field is also linked with the secondary winding, the voltage induced in the latter is sufficient to cause a spark to pass between the electrodes of the sparking plug. A voltage of about 3,500 is required for this purpose with a new plug and a compression pressure of 80 lb. per square inch. It will therefore be apparent that the voltage induced in the secondary windings will be dependent on the magnitude of the field associated with the primary (and consequently on the primary current) at the instant when the current is broken, and on the rate at which the field collapses, as well as on the number of turns on the secondary. Actually it can be shown that the quantity of energy stored in the primary field is equal to $\frac{L i_s^2}{2}$ joules, where L is the self-induction of the primary at "break" and i_s is the primary current at "break." In a well-designed magneto about 80 per cent. of this energy appears in the high-tension spark. The desirability of breaking the primary current at its maximum value is therefore evident, but unfortunately, for any given timing, the point at which the maximum current occurs is dependent upon the speed of rotation. The value of i_s can be determined if the form of either the flux or voltage-wave is known. The former can be obtained experimentally by the well-known "point-to-point" method, employing a search coil and ballistic galvanometer, and from it the voltage-wave can be deduced from the formula $e = \frac{-S_1 \, dN}{10^8 \, dt}$ in which S_1 is the number of turns in the primary. The same result can be arrived at more directly by means of an oscillograph. In any case, if the form of the voltage-wave is known the value of i_s can be determined graphically by a method previously explained by Mr. Young,* or it may be obtained mathematically by assuming the voltage-wave to be of triangular form; the latter method, also due to Mr. Young, is fully explained in an appendix to thepaper now under notice.

It is now necessary to consider what occurs in the secondary at the moment the primary current is broken. Actually the flux through the armature core reverses its direction at this instant, since the flux due to the magnets is restored as soon as the flux associated with the primary current disappears. The effect on the secondary, however, is equivalent to the sudden destruction of the flux resulting from the primary current alone, and it is convenient to consider the problem in this manner. It is evident that the factors affecting the rate of growth of

* See *The Automobile Engineer*, March, 1915.

the secondary voltage and the maximum voltage reached are the magnitude of the primary current broken, the self-induction of the primary at "break," the ratio of the number of turns in the primary and secondary windings, and the characteristics of the magnetic circuit. The latter should obviously be designed to allow the flux to die away as rapidly as possible—that is to say, large masses of metal in which eddy currents can exist should be avoided, as these retard the collapse of the field.

Another very important point in connection with the design of magnetos is the shape of the secondary voltage-wave, but unfortunately this is by no means easy to investigate experimentally. Mr. Young assumes that the secondary voltage rises suddenly to a maximum value and falls again to some extent before a spark actually passes. Once initiated, the discharge is, to some extent, maintained by the voltage induced in the secondary winding by the rotation of the armature or the inductor, but before this occurs the gases in the vicinity of the plug must be ionised by the difference of potential between the electrodes, and the explosion may even be initiated by the ionisation alone. In any case the maximum voltage reached will probably have a considerable effect upon the process of ignition. The shape of the voltage-wave also affects the rate at which energy is discharged by the spark, and, in Mr. Young's opinion, this is a matter of more importance than the total amount of energy liberated. Some useful information on this part of the subject will be found in an article by Mr. J. D. Morgan which appeared on page 427 of our last volume, but further research will be required before the process of ignition by a high-tension spark is fully understood, and this might well be carried out under the auspices of the Government.

The high-tension distributor, which is a very important part of a magneto, usually consists of a number of metal segments embedded in insulating material, each segment being connected to one of the sparking plugs. A carbon brush, connected to the secondary winding, bears lightly on the surface of the insulating material and makes contact with each of the segments as it rotates. With this type of distributor trouble is often experienced by carbon dust becoming embedded in the insulation and thus forming a path of comparatively low resistance between the segments. This "tracking," as it is called, causes misfires in certain circumstances, but if the carbon brushes are of such a quality that the working faces become polished, the trouble does not occur; the polish should therefore on no account be removed, as is sometimes done. A better method of avoiding the trouble is to use a distributor of the spark-gap type, in which a metal brush separated from the segments by an air gap about 0.01 in. in width is employed. This arrangement completely insulates the secondary, and thus enables the secondary voltage to attain its maximum value, whereas if actual contact occurs between the brush and the insulating material the maximum voltage may be reduced by leakage. Very satisfactory results, we understand, have been attained with distributors of this type, but it is necessary to allow of the escape of the ionisation products arising from the sparking inside the distributor by providing suitable ventilation openings, and these openings must be covered with fine wire gauze to avoid the risk of accidental ignition of any stray inflammable vapours.

The most vital parts of any magneto are obviously the magnets. Their function is to maintain a practically constant flux through the armature in spite of severe vibration and rapid temperature changes, which are inseparable from the working conditions—especially on aeroplanes. Such conditions, normally, have a most deleterious effect upon permanent magnets. It is also most important that the flux produced should be the maximum possible for a given weight, since it can be shown that the energy of the high-tension spark is practically proportional to the square of the flux through the armature. The design of the magnets, and the material of which they are constructed, must therefore receive very careful attention by magneto manufacturers. The magnets now produced in this country are made of hardened tungsten steel, and more than one British magneto manufacturer has expressed the opinion that they are at least equal, and in many cases superior, to the German product of pre-war days. The magnet industry, it must be remembered, has been developed in this country almost entirely since the outbreak of war, so that the satisfactory solution of the many difficult problems involved is an achievement upon which our steel manufacturers may well be congratulated.

Permanent magnets are usually compared by the product of the remanence and the coercive force, and it is the practice of the British Thomson-Houston Company, with which firm Mr. Young is connected, to determine these quantities for all magnets before they are fitted into a magneto. Those magnets in which the product of the remanence and coercive force, in C.G.S. units, is less than 580,000 are rejected, as also are those in which the coercive force alone is less than 55. Before use the magnets are ground on their edges and between the pole faces to limits of $\pm$ 0.15 mm. and $\pm$ 0.2 mm., respectively, to ensure the pole faces being parallel to each other and at right angles to the edges. These comparatively large limits are adopted because of the difficulty of grinding hardened tungsten steel magnets, which, owing to their shape, are particularly liable to spring, especially when grinding between the pole faces.

As previously mentioned, the bulk of the magnetos made in this country are required for aeroplanes, in which the working conditions are more exacting than in any type of motor vehicle. Reliability and elimination of fire risks are obviously matters of vital importance, and, at the same time, weight must be reduced by every possible means. Pioneer work of a particularly arduous nature had therefore to be done in the early days of the war, and the credit for this must be divided among the firms of Thomson-Bennett, the British Thomson-Houston Company, and the M. L. Magneto Syndicate. Examples of the products of each of these firms are given in Mr. Young's paper, to which we must refer our readers for full particulars. The M.L. machine dealt with is of the single-cylinder type, suitable for use with rotary engines, and the Thomson-Bennett machine is of the four-cylinder type. Both have rotating armatures and are based on Bosch designs, with many improvements in detail. A very full account of a British Thomson-Houston magneto for use with eight-cylinder engines is included in the paper. This machine has a fixed armature, with a rotating-sleeve inductor designed to give four sparks per revolution; a machine with a rotating armature cannot, of course, be made to give more than two sparks per revolution. A spark-gap distributor is employed on this magneto, we believe, with highly satisfactory results, and as evidence of this it may be mentioned that no signs of pitting on the brush could be detected after a continuous run of 300 hours at 2,500 r.p.m. The construction of the machine is, however, extremely complicated, and some idea of the organisation problems involved in its manufacture on a large scale will be gained if we mention that it contains no less than 860 separate parts, 397 of which are of different design. The number of different limit gauges required is 179, and as four complete sets of these gauges are in constant use, it will be obvious that their maintenance alone constitutes a very considerable item in the cost of production. A very complete analysis of the electrical characteristics of this machine is given in the paper, but as we have almost exhausted the space at our disposal we cannot follow the author in this. Another interesting magneto recently developed by the British Thomson-Houston Company is especially suitable for use with twelve-cylinder engines, though it can easily be adapted for eight-cylinder working. It is of the polar-inductor type, giving four sparks per revolution, so that with a twelve-cylinder engine it must run at 1½ times the engine speed. A very important feature of this magneto is that it is of much simpler construction than the sleeve-inductor magneto above referred to, and consequently the problems involved in its production in large numbers are more easily solved. This should result in a considerably increased output as soon as the arrangements for manufacturing the new type are completed.

Mr. Young gives many valuable hints on the installation and care of magnetos, pointing out particularly the importance of accurate alignment between the driving shaft and the shaft of the magneto, and also calling attention to the fact that the steel straps frequently employed for fixing magnetos provide a leakage path for the magnetic flux, which, in a particular case cited, would result in a loss of about 12 per cent. of the energy output of the magneto. If straps are employed it is therefore desirable that they should be made of phosphor bronze, or some other non-magnetic material.

We are in complete agreement with Mr. Young's concluding remarks, which deal with the problem of securing a magneto that will be in all respects a British production. To achieve this it is not only necessary for the manufacture to be carried on in this country, but the whole of the materials required for construction should be obtained from sources within the British Empire, as otherwise this very important industry might be seriously handicapped in some future war. As an example of a state of affairs that might be improved we may mention that the very fine mesh varnished silk now used for insulating the armatures of magnetos is woven in Japan, sent to America for varnishing, and thence imported into this country, though the resources of the Empire are certainly capable of supplying all that is required for this material. It also appears that British manufacturers are not, at the moment, capable of meeting all the demands of magneto manufacturers for articles such as moulded insulating goods, carbon brushes, and die castings, though, considering the shortage of labour and general pressure of war work, the progress already made in this direction is highly commendable. Doubtless a more complete co-operation between the manufacturers and users of these goods will produce an improvement even under existing conditions, and if continued after the war it should do much to ensure the maintenance of the new British industry.

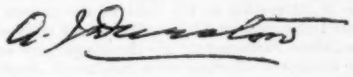
THE LATE SIR A. J. DURSTON, K.C.B.

As we briefly announced in our last issue, with much regret, Sir Albert John Durston, K.C.B., died at his residence at Blackheath on the 18th inst., after a brief illness, owing to internal malady. He was in his seventy-first year, and during one-half, or 35 years, of his life he had exercised a powerful influence on the development of naval engineering, alike in respect to design and construction. For 18 years he had been Engineer-in-Chief of the Fleet. He began his tenure of this office at a period of considerable stress from the engineering point of view, as those responsible for the propelling machinery of ships had been unduly pressed to reduce weights for the legend power, in order that other fighting qualities might be augmented without reduction of speed. The consequence was considerable uncertainty as to the maintenance of those speeds for prolonged periods, and frequent breakdowns when the machinery was required to maintain full power for any length of time. Being a sound practical engineer, ready to encourage experiment, and with a considerable degree of courage, he moved step by step towards the introduction of higher steam pressures, and the introduction of water-tube boilers in substitution for the old heavy tank boilers, thereby greatly reducing weights. At the end of his term of office he had overcome the earlier difficulties, and had also initiated the use of steam turbines in all types of ships, even the largest, in preference to the old reciprocating engine. It is true that vast strides have been made since his relinquishment of office in 1907, but this, instead of lessening the credit due to him for his progressive work, only tends to enhance it, a fact which is recognised not only by everyone connected with the service who came under his influence, but by the great naval manufacturing firms throughout the country. Official recognition was given by his being made a C.B. in 1895 and a K.C.B. in 1897.

Like so many naval men, the subject of our memoir was born in a naval port, Devonport being his birthplace, the date October 25, 1846. He completed his general education as a pupil of Mr. Robert Barnes, of Newport, Isle of Wight, and at the age of 15 years obtained, in open competition,

an engineer studentship in Portsmouth Dockyard, then under the direction of the late Mr. Andrew Murray, a well-known shipbuilder and engineer. He served for five years and five months at the Dockyard, passing through practically every department and gaining a comprehensive experience of the engineering side of his profession, which greatly influenced his attitude in tackling engineering problems in later life. He was entered as "second-class assistant engineer, R.N.," in June, 1866. He was studious in his habits, and in 1865 gained a studentship in the Royal School of Naval Architecture in South Kensington, founded in the previous year. Curiously enough, he had as contemporaries Sir William White, Dr. Elgar and Richard Sennett, with whom, until their deaths, he continued in close association. He obtained the diploma of a third-class Fellow of the School in 1868. His first commission was in H.M.S. Ocean, on the China Station, where he continued for three years. Shortly after his return to England he was appointed, on October 11, 1872, to Portsmouth, and from this time forward he continued to serve in the design and constructive departments of the engineering staff of the Navy. In 1877 he was promoted to chief engineer, and four years later was transferred to Sheerness Dockyard as the head of the engineering department there. He returned to Portsmouth Dockyard as chief engineering manager two years later. His advance in rank was rapid, as he became Fleet Engineer in February, 1886, and Inspector of Machinery in December, 1888. A month earlier, however, he had been appointed for service at the Admiralty, on the staff of the late Mr. Richard Sennett, and within five months he succeeded Sennett as Engineer-in-Chief of the Fleet, on the retirement of his chief to take up a position at Messrs. Maudslay's engineering works. Durston was promoted to be Chief Inspector of Machinery on November 18, 1893, and his title was altered, under the new nomenclature, on April 1, 1903, to Engineer Rear-Admiral. On January 1, 1906, he was promoted to Engineer Vice-Admiral.

[*From a photograph by Elliott and Fry.*



We have indicated the difficulties associated with the naval machinery when Sir John Durston first took office as Engineer-in-Chief of the Fleet. To overcome those troubles he worked consistently, cautiously, but with quiet persistency. At that time steam pressures over 150 lb. in naval ships were rare. The tendency was to subject the boilers to a high degree of forced draught in order to get the full power. Thus the heating surface had been reduced to 1.7, or at most to 1.8 sq. ft. per unit of power, and leaky tubes became a frequent source of trouble. Ferrules were adopted as an expedient; then came the formation of "bird's nests" at the junction of the ferrules with the ends of the tubes. The water-tube boiler with small tubes had been introduced into small craft, while in the French navy Belleville and other boilers with large water tubes were in successful operation. Sir John Durston took the bold step of developing further a small-tube—then known as the "Express"—boiler in small craft, and, after careful investigation and test, adopted the French type of boiler for large ships, at the same time practically doubling the steam pressure. The first large ships fitted with the system were the Powerful and Terrible, laid down in 1895.

Public servants are subjected to criticism; they are prepared for it; but in few cases has there been so intense an attack made on any development in engineering as in connection with this departure at the Admiralty. Sir John Durston, however, firm in his conviction that the departure was along the right road, continued in his course, without having the satisfaction of the right or opportunity to defend his actions in public. During his tenure of office two technical committees investigated the question of boilers, in 1892 and 1900, and in both cases it was established that his action was consistent with the knowledge and resources available. Other types of boilers were developed in this country, and Sir John Durston was able, before retiring from office, to dispense with the Belleville type, which, however, is still in use in the French and one or two other navies, and is giving satisfaction in the British navy. The change not only gave higher steam pressures, and thereby conduced directly to increased power, but it was found possible to increase the heating surface of the boilers from 1.8 to from 2¼ to 3 sq. ft. per unit of power, so that full power was developed for much longer periods and with greater reliability. At the same time it was found possible to get from 10 i.h.p. to 11 i.h.p. per ton weight in cruiser machinery, as compared with 8 i.h.p. to 9 i.h.p. when Sir John Durston became Engineer-in-Chief, while in the case of the boilers alone the increase was from 14 i.h.p. or 16 i.h.p. to from 18 i.h.p. to 22 i.h.p. In the old days four hours was considered long enough for a full-power trial, whereas before Sir John demitted office eight hours and more was the minimum period. To show that he achieved this result without unnecessarily cutting down weights, it may be added that the natural draught power per square foot of grate surface was decreased during his régime from 12 i.h.p. or 15 i.h.p. to 10 i.h.p. or 13 i.h.p. When forced draught had been applied each square foot of grate surface was supposed to be equal to the development of nearly 20 i.h.p. Thus the boiler question was settled. At the same time many improvements in reciprocating engines had been made, further to equalise the steam consumption at widely varying percentages of the full power, a problem which greatly affected the radius of action of the warship. In those days the result of cruising at from 20 per cent. to 30 per cent. of the full power was a much higher consumption per unit of power developed, owing particularly to the large steam-eating qualities of the auxiliaries, and in these, as well as in the main engines, Sir John Durston was able to make many improvements. But, as regards the main engine, the greatest step was taken by the application of the Parsons steam turbine, first in destroyers—in H.M.S. Eden, completed in 1901, in cruisers—in H.M.S. Amethyst, completed in 1905, and in battleships—in H.M.S. Dreadnought, completed in 1906. This began a new era in the development of naval machinery, but Sir John having reached the age limit in 1906, and having been granted a year's extension, in 1907 relinquished to his coadjutor, Sir Henry Oram, the office of Engineer-in-Chief of the Fleet and the work of "carrying

on." Sir John Durston became a member of the Institution of Naval Architects in 1897, and, after serving a long time on the council, was elected, first, vice-president, and later, honorary vice-president. He was elected a member of the Institution of Civil Engineers in 1897, and of the Institution of Mechanical Engineers in 1899. From time to time he gave the technical institutions the benefit of papers dealing with developments in naval machinery, and in this way was able to explain to his critics in the profession the reasons for his actions and the results accruing therefrom. This, however, did not meet the case of the Parliamentary critic, but there can be no question of the sympathy of the engineering profession and its recognition of the splendid work done. This is in part established by the fact that he was awarded by the Institution of Civil Engineers a Telford premium and the Watt and Stephenson gold medals. He was also president of the Junior Institution of Engineers and of the Institute of Marine Engineers. His address to both of these organisations was characteristically devoted to naval machinery. Indeed, as he was of a modest, retiring temperament, his incursions into public debate were largely dictated by his sense of public duty, his desire being to educate the public, as well as his fellows in the profession, on the work being done by himself and his colleagues in the Navy.

When he relinquished office in 1907 the Lords of the Admiralty formally recorded their expression of high appreciation of the distinguished services he rendered to the Royal Navy during the period of his appointment, and in October, 1916, a further recognition was granted in the awarding to him of a "good service" pension of 200*l.* a year, in addition, of course, to his ordinary service pension. In recent years he has not taken much part in public life, but nevertheless the notice of his death has been read with widespread regret, and sympathy is extended to his family, three sons and four daughters; his wife, to whom he was married in 1869, predeceased him 30 years ago.

RAILWAY LABOUR CONDITIONS.

IN our last issue we published two agreements which have been entered into by the Railway Executive Committee with the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen in one case, and in the other with the National Union and the Railway Shops' Organisation Committee of Craft Unions. The principal feature of these agreements is that, under them, the war bonus granted to railwaymen has been further increased by 5*s.*, at an annual cost of over 7,000,000*l.*; but there are incidental features in connection with the most recent negotiations that are of wide interest. For the first time the negotiations were carried on by the Railway Executive Committee on behalf of the Board of Trade, and it was placed on record that the several general managers were not representing individual railway companies, but were acting for and at the request of the Government. We understand that in connection with previous negotiations a full meeting of all railway companies' managers was summoned, a representative committee appointed, and the requisite mandate to act for all the companies given. With the growing financial burden represented by the war bonus, the companies felt that they could no longer be parties to negotiations with the trade unions and that the matter was one for the Government. Hence the new basis of negotiations; hence, also, the fact that no question has arisen as to the cost of the new grant being borne by the Government. But it is fair to assume that the companies must have been desirous of dissociating themselves from participation in responsibility for the enormous growth of their wages bills while their property is temporarily under State control. Since the war commenced the trade unions have succeeded in obtaining war bonuses and increases of wages the aggregate cost of which is not less than 22,000,000*l.* per annum. Well may certain labour members advocate nationalisation of railways, and it may be something more than intelligent anticipation of favours to come that is responsible for the statements—often claimed as originating with "a Cabinet Minister"—that the railways will never return to company ownership. Railway companies, however, cannot afford to allow their expenses to be unduly increased without placing the facts on record. So far as many grades of railwaymen are concerned there is no doubt that there was a case for advancement of wages; but by granting a flat rate war bonus inequalities have been accentuated. Thus, while labourers and platelayers in remote country districts are now being paid 35*s.* per week or more—equal to 8*d.* or 9*d.* per hour—there are engine drivers paid 48*s.* and 50*s.* per week, notwithstanding their much greater skill and responsibility. Then there are platform porters in London and large towns to whom 35*s.* is being paid, which is increased to 55*s.* or even 65*s.* per week by "tips." Railway companies have been compelled to recognise "tips" in workmen's compensation cases, and they are therefore entitled to reckon them when considering wages questions. We suggest that the time has come when the companies should make known the service conditions of their men, in order that the public may judge whether they are adequately remunerated. Shareholders cannot regard with equanimity the handing over of millions of money to employees every few months without some reasonable prospect of passing on the cost to the consumer of transportation after the war when the temporary control by the State ceases.

Another feature of the recent negotiations is the fact that for the first time the Railway Shops' Organisation Committee of Craft Unions appeared with the National Union of Railwaymen on behalf of craftsmen and workshop employees. So far as the staffs of the mechanical engineers of several lines are concerned there have been various applications to the Committee on Production, and the general result has been the granting of wage increments amounting to 4*s.* per week, with 10 per cent. increase of piecework prices. In September last this was supplemented by a war bonus of 5*s.*, and that sum has now been increased to 10*s.* per week, with the proviso that the war bonus will not be paid to shopmen who are in receipt of the recognised district rates of wages and who may benefit under the terms of the award issued by the Committee on Production on March 1, 1917, upon an application made by the engineering and foundry trades. Railway companies do not usually pay the trade union district rates; in fact the Great Eastern Railway were recently successful in resisting a claim that such rates were applicable to employees in their works. But in some instances, *e.g.*, the Great Central shops at Manchester, we believe that trade union conditions apply. There have also been other instances in which such conditions have been introduced in individual shops in consequence of railway employees having been granted leaving certificates by Munitions Tribunals on the ground that the railways were not paying the rates of the district. In all such instances the new war bonus will not be paid. These, however, will be a small minority, and, generally speaking, railway shopmen will be paid 10*s.* per week war bonus in addition to 4*s.* per week advance of wages granted by the Committee on Production. We may assume from this that the trade unions have recognised a distinction between railway workshops and ordinary engineering establishments, and that railway and district rates of wages and conditions will not be identical. This is interesting in the light of the powers proposed to be conferred by the Munitions of War Bill now before Parliament, viz., the compulsory extension of awards affecting craftsmen to all employers and workmen engaged in the same trade. We may here explain that the trade unions who were parties to the agreement with the Engineering Employers Federation are with few exceptions also included in the Railway Shops' Organisation Committee of Craft Unions, so that there is little likelihood of any question arising as to the binding character and scope of the agreement with the Railway Executive Committee.

Neither of the two agreements now made between the Railway Executive and the several trade unions contains any clause as to duration. Doubtless this is due to the experience of the railways following the agreement of October, 1915. It will be remembered that the 5*s.* per week war bonus was accepted as a final settlement for the period of the war, and the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen undertook not to present any fresh demands for increase of bonus or wages, nor to countenance or support any demand to reopen the settlement. The finality sought was not found, and the only undertaking now given by the trade unions of railwaymen is to respect the "truce" agreement of October, 1914. It is that the conciliation scheme is to remain in operation, as also all contracts and conditions of service, and no agreement is to be made by the companies either with deputations or conciliation boards during the operation of the "truce." We are inclined to the view that it was wise to omit any reference to a period of operation of the settlement. Conditions are changing rapidly, and it would be impossible to gauge the future with any degree of certainty. The only really useful system is that which has been accepted by the Engineering Employers' Federation. In the agreement with the trade unions it is stipulated that the Committee on Production shall in the months of February, June and October, after hearing the parties, consider what general alteration in wages, if any, is warranted by the abnormal conditions then existing and due to the war. Without binding the parties to a sliding scale based on Board of Trade statistics of increased cost of living or any other data—a principle rightly objected to by the railways—there is no doubt that periodical reviews of labour conditions are essential in present circumstances.

We append a summary of the various agreements in regard to the railway employees' war bonus:—

	Oct., 1915. Per Week.	June, 1915. Per Week.	*Oct., 1915. Per Week.	Sept., 1916. Per Week.	Nov., 1916. Per Week.	April, 1917. Per Week.
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Employees, 18 years of age and over, at 30*s.* per week or more	2 0	2 0	} 5 0	10 0	10 0	15 0
Employees, 18 years of age and over, at less than 30*s.* per week ..	3 0	3 0				
Boys under 18 years of age	—	1 6	2 6	5 0	5 0	7 6
Female employees, 18 years of age and over	—	—	—	—	3 0	5 6
Female employees under 18 years of age	—	—	—	—	1 6	3 9

* Workshop employees generally did not receive this bonus, but were granted advances of wages and piecework prices. In September, 1916, one-half the amount of the bonus to railwaymen proper was granted to shopmen, and this has now been increased to 10*s.* per week in the case of men and 5*s.* to boys and women.

THE LATE MR. ANDREW S. BIGGART.

MR. ANDREW S. BIGGART, of whose death, at his residence at Pollokshields, Glasgow, early on the 26th inst. we learn with regret, was for 35 years closely identified with the bridge-building industry, and by his ingenuity as an engineer did much to simplify and render less costly constructional operations. Trained as a mechanical engineer and intimately associated with the late Sir William Arrol for 34 years, he had developed, and exercised in all his work, a sound mechanical line of thought and action, and thus was able from his experience to devise means of efficiently accomplishing work of considerable magnitude with admirably arranged plant. Since Sir William's retirement from active participation in the business of the firm, Mr. Biggart has done work in various parts of the country, which, if not of such striking magnitude as some earlier work of Sir William Arrol, is notable for the difficulties attendant upon erection operations.

Mr. Biggart was born at Burnhouse, Beith, on August 25, 1857, and received a general education at private schools and at the High School at Glasgow. He entered upon his practical training when 16 years of age in the machine shops of Messrs. W. King and Co., marine engineers, of Glasgow, serving afterwards in the fitting and pattern shop; as the establishment was a comparatively small one there was greater variety of work and more extensive opportunity for wide training. This applies also to the subsequent part of his training in the drawing office of Messrs. Matthew Paul and Co., of Dumbarton, where he continued until 21 years of age. He was for a short time in the works of Messrs. William Forrest and Co., Limited (late Forrest and Barr), engineers and millwrights in Glasgow, and in the drawing office of the Rose Hill Engine Works. Following upon this general training, he entered the service of Messrs. William Arrol and Co., of Glasgow, in 1879, as a draughtsman.

becoming almost immediately head draughtsman, and a year later chief engineering assistant to Sir William Arrol. The Arrol Company had by this time established a high reputation, not only for bridge building, but for constructional steel work, principally roofs.

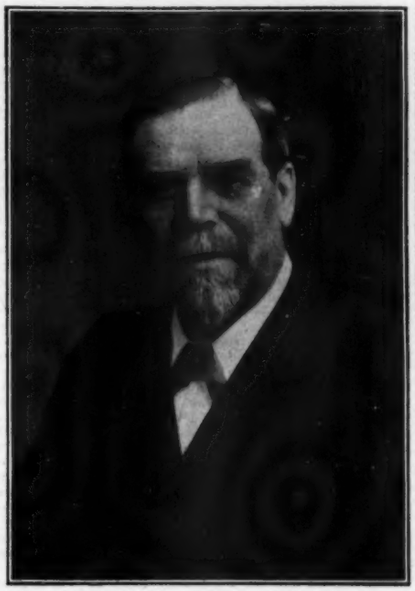
In 1882 the contract for the construction of the Forth Bridge was entered upon by Sir William Arrol, and Mr. Biggart was directly associated, under his chief, in laying out the workshops at the site of the bridge and designing the plant for construction. There is no need here to enter upon any description of the methods adopted. It was recognised that the bridge, striking as it was in the originality of its conception, was remarkable also in almost equal degree for the ingenuity exercised in the construction of the plant, particularly in connection with the building up and riveting of the tubes forming the lower members of the cantilever arms. Here it may be interjected that it was a deserved compliment that the Forth Bridge Railway Company paid to Mr. Biggart in entrusting the firm with the reconstruction of the floor, a work which is now approaching completion. During the progress of the erection of the bridge he contributed, almost annually, a paper on one or other of the interesting features of the constructional work at the Forth Bridge to the Institution of Engineers and Shipbuilders in Scotland, and for this he received the Institution gold medal. He received the Railway Engineering gold medal from the same Institution for his papers on the Tay Bridge. The Forth Bridge also formed the subject of a paper read at the Manchester meeting of the British Association in 1885, while another phase of the subject was dealt with in a paper on wire ropes, printed in the Proceedings of the Institution of Civil Engineers in 1890.

The most notable examples of the bridge building with which Mr. Biggart was identified included the long viaduct over the River Barrow in Ireland and that over the River Suir in the same vicinity; the reconstruction of the Swale Bridge for the South-Eastern and Chatham Railway, and a public road; the construction of the Rodah Bridges at Cairo; the new bridges over the Walney Channel and the dock entrance at Barrow-in-Furness; and the building of the Great Central Railway and road bridge over the River Trent at Keadby. All of these bridges have a Scherzer opening span, and it may be said that the Arrol Company, of which Mr. Biggart was chairman, has done more than anyone in the application of this principle in this country. The last-named structure has the heaviest of such opening spans, the total weight being 2,900 tons. Mr. Biggart took the full charge and responsibility of its erection. Another of his striking examples of bridge work is the double-deck bridge, of massive construction, over the Wear at Sunderland, a building which, like the Forth and other bridges, was erected by overhang, all the more striking, as the weight of the main span was 3,000 tons. He also recently erected a "conveyor" bridge over the Tees at Middlesbrough. He was responsible for the work of widening the Blackfriars Bridge across the Thames, finished in 1909, and up to the time of his death was deeply interested in the building of the new Southwark Bridge.

In this last-named instance one finds full example of that breadth of view which characterised all his work. The policy of his firm was to devise and erect temporary plant, almost irrespective of cost, in order to accomplish the work necessary in the shortest possible time and at the minimum of expense, hoping always to utilise much of the temporary plant in subsequent operations. Those engineers who have visited Southwark Bridge have been impressed with the efficiency of the temporary plant. The money it costs is no doubt returned many-fold by the economy in construction of the permanent work; that is a point that contractors do not always fully consider. Another important contributory to the success of such constructional steelwork was the establishment many years ago of a highly-qualified designing department, so that designs made conformed to requirements in connection with building operations. Mr. Biggart had extensive experience in the sinking of deep foundations under air-pressure. Many of the bridges already enumerated—notably, that over the River Barrow in Ireland—involved most careful work in the preparation of the foundations, the depths attained in the instance mentioned being over 100 ft. below water level. Although over 100 cylinders and caissons have been dealt with in a comparatively short time there has been no serious accident, a tribute to the care in design and construction of the necessary mechanical appliances and to the exercise of moral force and example in applying disciplinary measures amongst those engaged.

As with many other departments of work, the Forth Bridge was the beginning of an important mechanical engineering department, in which Mr. Biggart found much scope for his ingenuity. All the plant required on works was practically made by the firm, and this led them into the manufacture, for others, of cranes, presses, riveting machines, pumps and the like. The study of hydraulics, in association with the late Mr. Foulis, gas engineer of Glasgow, led to Mr. Biggart taking up the subject of gas-stoking plant, and many appliances of this nature were fitted, not only to London gas works, but others, in Vienna, Berlin, Amsterdam, &c. This department of work formed the subject of the only paper he read at the Institution of Mechanical Engineers, on "Hydraulic Stoking Machinery and Labour-Saving Appliances in Modern Gas Works," in 1895.

Mr. Biggart was made an Associate Member of the Institution of Civil Engineers in 1887, when he was engaged on the Forth Bridge, and it was appropriate that his nomination form should be signed by the great engineers who had designed that structure. He became a full member in 1887, but his most numerous technical contributions were to the Glasgow Institution. In addition to those already mentioned, he dealt broadly with steel structural work for



THE LATE MR. ANDREW S. BIGGART.

buildings contributed in 1897, and his more recent bridge building work was dealt with in a contribution in 1909. He was honorary president of the Glasgow University Engineering Society in 1904, and in his presidential address, dealt with the training of engineers and the prospects of engineering students.

Mr. Biggart, although he had advanced with the development of modern mechanical conditions, belonged to the old school in respect that he sought for personal influence over all his workers and was eager to ensure their welfare. He was a director of the Glasgow Workmen's Dwelling-houses Company, Limited. In the education and advancement of his apprentices he took a great interest, and for many years served as a governor of the Royal Technical College, Glasgow. He was a director, too, of the Scottish Temperance Life Assurance Company, Limited, from 1910, and chairman of the North-West Engineering Trades Employers' Insurance Association in 1911.

In 1905 he, with his brothers and sister, founded a memorial to his father and mother and his two deceased brothers, in the shape of a hospital home for cripples on the shores of the Firth of Clyde. The site embraces 6 acres of land, and the building has since been considerably extended. In other ways Mr. Biggart was liberal in benevolence, and his striking characteristics of unobtrusiveness and solicitude for others, combined with a shrewd-minded capacity for guiding counsel, gained for him a wide respect. He succeeded Sir William Arrol as chairman of the company in 1913, having been for a considerable time before this a managing director. Since the war he gave the benefit of his ability and experience as a member of the Board of Management for the Ministry of Munitions dealing with Glasgow and the West of Scotland. For some time he suffered from an affection of the heart, and died from such cause early on Thursday, He is survived by his widow, six sons and three daughters, with whom wide sympathy is entertained.

THE LATE MR. WILLIAM HAMILTON MARTIN.

WE regret to have to announce the death, which occurred on Thursday, the 19th inst., at Rotterdam, of Mr. William Hamilton Martin, engineering manager of the Royal Shipbuilding and Engineering Company, "De Schelde," Flushing. Mr. Martin served his apprenticeship with John Elder at his Glasgow works, and went to Rotterdam when still a young man. In the early 'eighties of last century the Royal Dockyard at Flushing was taken over by a private limited company, and the docks were reorganised by the late Sir William Pearce, of the Fairfield Company, with Mr. Martin as engineering manager. For some years afterwards the work carried out was of a general character, but as Mr. Martin's speciality was that of marine engineering he applied himself assiduously to that class of work, and under his direction the Flushing yard gradually developed into one of the largest shipbuilding and engineering works in Holland.

Mr. Martin was a most capable and most enterprising engineer. He made frequent tours through the principal works in Great Britain to ascertain what were the latest tools and methods of manufacture, and spared no effort and money to maintain at a high standard the installations at the Flushing yard; it is not surprising, therefore, that his company commanded a fair share of Dutch Government work. He has built all classes of Dutch war vessels, from the largest cruisers to submarines, and he has been uniformly successful in the production of machinery of excellent quality, second to none of its class built anywhere. He has also built a large number of handsome vessels for the principal Dutch shipping companies, including the Rotterdamsche Lloyd, the Java, China and Japan line, the West Indian Mail Steamship Company, the Koninkljke Hollandsche Lloyd, and others.

Mr. Martin was a thorough optimist; he was always keen upon trying new devices and material, even to taking progress by the forelock. For example, when the quadruple expansion was started he went a stage further and built a six-stage expansion engine for the steamship Thor VI, to work at a 250-lb. boiler pressure, and although it did not prove to be an unqualified success and was not repeated, the fact illustrates the character of the man. He was early in his application of the water-tube boiler, notably of the Yarrow type.

He was a member of the Institution of Naval Architects from 1893, and regularly attended the meetings in London, but did not take part in the discussions. He was also, from 1886, a member of the Institution of Mechanical Engineers, and was a notable attendant at the summer meetings. He was associated with Messrs. J. Stone and Company, Limited, Deptford, in the matter of manganese bronze, and with Mr. Andrews, of Andrews and Cameron, Kirkintilloch, in Martin and Andrews' double-opening balanced slide valves, which were first fitted in Flushing, and introduced by Mr. Andrews in this country.

Mr. Martin was a Knight of the Order of the Netherlands Lion, and was 66 years of age at the time of his death.

THE LATE MR. THOMAS KENNEDY.

WE regret to have to announce the death, which occurred last Friday, the 20th inst., at his residence in Kilmarnock, of Mr. Thomas Kennedy, managing director of Glenfield and Kennedy, Limited. Mr. Kennedy was 79 years of age and had been in failing health for some time past. He was born at Oban, and served his engineering apprenticeship at Greenock For several years afterwards he served on board ship, and in the course of his career on the sea he assisted in the laying of the first Atlantic cable. Whilst still a young man he settled in Kilmarnock, where he worked in association with his uncle, the maker of the Kennedy patent water meters. He was then and for a period of over fifty years prominently identified with the firm of Glenfield and Kennedy, Limited, the well-known engineers and makers of hydraulic machinery, of Kilmarnock; the development of the works, which now enjoy a premier position in its various specialities, was largely due to his exceptional ability and skill as an engineer, his organising powers, his untiring industry and his devotion to duty. Mr. Kennedy was a J.P. for Kilmarnock, and a member of the Institution of Mechanical Engineers since 1892.

BRITISH COALING PLANT AT DURBAN.—The Imperial Trade Correspondent at Durban has forwarded to the Board of Trade an extract from the *Natal Mercury* containing particulars of a new British coaling plant which has recently been installed at Port Natal. The plant is stated to be the only one of its kind in South Africa, and it is claimed that it is one of the largest belt-conveyor installations at present in operation for coaling vessels. The plant has been designed to load 600 tons of coal per hour; this result is easily attained.

CONTINUOUS ENAMELLING AND STOVING MACHINE FOR SMALL PARTS.

We illustrate on the opposite page a somewhat novel machine manufactured by Messrs. Lacy-Hulbert and Co., Ltd., at their works, Beddington, Surrey, from a photograph of the plant erected temporarily. The view shows a machine for enamelling and stoving by continuous mechanically effected rotation a great variety of parts of different shapes and sizes, up to a rate of 2,000 parts per hour with the attendance of only two unskilled operators. The machine thus fulfils the aim of the designer in reducing to a minimum the labour required for the work, which consists of enamelling small light intricate castings and stampings, which are particularly awkward to paint by hand and, in the ordinary way, take up a lot of space and time for the drying or stoving process.

The machine which we illustrate consists of two distinct units, the painting or enamelling machine and the stoving machine. Dealing first with the painting machine—this consists of a table on which is mounted a vessel in the form of a tube or tunnel through which the articles to be painted are passed at a uniform speed and at a uniform distance from each other by means of an endless chain and wheels driven by a small electric motor. Each part to be painted is hung on a specially-prepared hook, and these hooks are so made that they ensure the various parts being kept at an equal distance from each other. The speed at which these parts pass through the tunnel can be up to 2,000 per hour, and the distance of each part from the other can be varied to suit the requirements. On each side of the tunnel are placed two or more pneumatic paint-spraying machines, which operate through coned openings at the sides of the tunnel and are so disposed as to ensure the paint from the sprays reaching all the surfaces of the article being painted during its passage through the tunnel. The excess of paint, fumes, &c., is carried away by means of a fan and is separated, so that a large proportion of the paint may be recovered and the air discharged practically clean. The paint thus recovered may be used over again. After passing through the painting unit each article is deposited automatically by the machine on a small rod which forms the connecting link between the two units of the apparatus.

The second unit, a continuous stoving machine, consists of a rectangular chamber about 16 ft. long by 4 ft. wide, heated by suitable gas jets and fitted with a sliding door at the rear end, as seen in the illustration. Two continuous chains with suitable sprockets are provided, one on each side of the machine, and operated by a handle so arranged that at each revolution of the handle the chain travels longitudinally inside the stove a distance of about 4½ in. These chains are provided to carry rods on which are suspended the parts which have been painted. These rods, which are loaded by the painting machine, are placed on the chains by the operator at a rate corresponding to that at which they are charged by the painting machine, and each rod travels through the stove at a rate equal to that of the number of revolutions of the travelling handle. The result is that by the time the parts on any one rod have travelled through the whole length of the stove they will have been subjected to the heating for a definite period and the stoving operation completed. At the far end of the stove the articles on their rods are carried down an inclined plane, where they can be allowed to cool before being disposed of.

The apparatus as above described can be worked, as we have said, by two unskilled operators, and as surplus paint is collected and the fumes both from the painting machine and stoving apparatus are carried away in suitable flues, the whole operation is conducted in a very clean and methodical manner. The power required is negligible beyond that needed for the supply of compressed air, which is used at about 30 lb. per square inch, supplied from one of the makers' class "Y" patent air compressors.

The general dimensions of the machine here illustrated are:—For the painting machine, 7 ft. long, 3 ft. wide, 8 ft. high; for the stoving machine, 16 ft., long, 4 ft. wide, 4 ft. 6 in. high. But these two units are so designed that they have to be placed at right angles to each other, as shown in the illustration. The production in parts of average size within the limits of the machine is at a rate up to 2,000 articles enamelled and stoved per hour, the time occupied by each article going through two units being about 30 minutes. These times may be varied and adjusted to suit the requirements, and larger and smaller machines can be made on the same lines to suit the production of parts of various sizes in large quantities, the apparatus being essentially designed for large production of repetition work. Paint which is sprayed on gains access to holes and recesses more thoroughly than that applied with a brush, and consequently the machine should protect the articles passed through it from oxidation very thoroughly, and should do so at a minimum cost.

CUTTING AND CHIPPING OF GLASS.

To the Editor of Engineering.

SIR,—The use of the diamond in dividing plane surfaces of glass, though it is said to date from the 16th century, is one of those processes in industry which are the less heeded in proportion to their specific adaptability and apparent simplicity than should be the case.

Lord Rayleigh's most interesting letter in your issue of February 2, on the "Cutting and Chipping of Glass," has, I am sure, whetted the appetite of many for a paper upon this difficult subject of the cutting diamond from his learned pen. Hertz's theory and his diagram of the lines of principal stress in the (x–z) plane in the neighbourhood of a compressed area on the surface of an elastic solid certainly helps us in our expectation of what may happen in rupture. But it would appear that the edge of a cutting diamond sinks into glass before the rift takes place, and this may modify Hertz's diagram.

French (see ENGINEERING, vol. cii. p. 492) seems to have established the existence of two forms of glass when polished—the original brittle material, which he calls alpha glass, and the plastic surface layer, which he calls beta glass. If Lord Rayleigh himself has not expressed definite views upon the existence of this modified layer he appears to have thought that there was something of the kind (see *Nature*, 64, 1901, p. 385).

If a glass surface be ever so lightly covered with soot from a smoky flame and then the diamond drawn across the smoked surface with various degrees of pressure, the path of the diamond presents a curious appearance under the microscope. The track is generally made up of two parts: a track with just a surface layer of soot lightly swept away, and a narrower track in the centre of this with the soot particles pressed into close contact with the glass. The wider track is swept out by a very minute quantity of soot or dust which accumulates in front of the advancing diamond. It is, however, sometimes absent. But the narrower track—the true track—appears to be due to the diamond edge actually sinking into the glass and squeezing the soot against the sides of the elastic trough so formed, for the breadth of this track depends upon the pressure, varying from 0.035 to 0.004 mm. in some experiments I did. The thickness of this sooty layer can only be some few wave-lengths of light. When the pressure was enough to cause a rift the surface-cracks on the glass did not appear to extend beyond the boundary of the true track laterally, and in the particular ¼-in. plate glass I used only if the track exceeded 0.030 mm. did the glass rift!

I have never seen a diamond rift without its attendant surface-cracks. Sometimes the thin and transparent sooty layer in this true track assumes a beautiful appearance, not unlike the backbone of a fish with the vertebral spines and ribs directed towards the advancing edge of the diamond. These lines are evidently ruptures in the sooty film. The line, corresponding to the vertebræ in the simile, along which the actual edge of the diamond has travelled is ill-defined by intact soot, and a hasty conclusion might lead one to think that the crystal edge never actually touches the glass. This requires careful examination.

The hiss—I use the word with diffidence—of a good diamond doing its work and the regularity and beauty of the scalloped border of the cut in the plane of the rift are remarkable. Is the former due to the discontinuous velocity of the front edge of the snapping rift as the diamond uniformly advances? With what speed does a rift travel, and to what depth? These are big questions with regard to minute things, the answers to which should also give a mathematical solution to the fissures in glaciers.

It has been stated that glass hardened by De la Basties' process cannot be cut by the diamond. Brittle resins can be rifted by the sharp edge of a knife, and so can toffee. The splitting of ice by a needle and the easy fragmentation of sheet glue with the point of an awl—usually smashed with anvil and hammer and projected to the four corners of a workshop—are examples of Hertz's theory.

I believe that Cailletet was the first to show that if crystalline salts, say 6 per cent. of potash alum, are added to strong glue which is spread over a glass surface, the "chipped" pattern produced is more remarkable. He states that a thin cylinder of glass will split into a hemi-cylinder when so treated. In "Recipes, Formulas and Processes," by G. D. Hiscox, the action of varnish is described, and it is stated that a single coat gives a small delicate effect, whilst a thick film produces a large and bold design.

The "chipping" of glass, the great force of the contraction of the colloid, and the extraordinary adhesion between the two are certainly remarkable phenomena.

Yours truly,

ALAN POLLARD.

Birkhead, Ardrossan, April 19, 1917.

THE METRIC SYSTEM.

To the Editor of Engineering.

SIR,—May I point out that in case you accept the metric system and use it in your colleges then and in your technical books, this will help you much in fighting the Germans commercially.

The German industry has developed so tremendously partly owing to its colleges and technical literature, as both make you acquainted with their manufactures. In case you want some machinery you sooner will go to a firm whom you know, owing to your college books, than that you will go to some other country, of whose manufacturers you only know through the catalogues they send you.

Consider my special case; I am a Dutchman, I studied at a German polytechnikum and worked as improver in England for practical experience (this was also for personal reasons; the German students made me loathe German life so much that working in a factory, which is never pleasant, I would not do there). I have been using German books, which you will admit are good for electrical engineering, and found some of your English books on that subject even better with regard to explaining the subjects and giving very practical and valuable data. For electrical engineering you sometimes use the metric system, but, taking one example, applied mechanics, which has to be used in every branch of engineering, I could not get books in the metric system. The book on this subject by Professor Goodman is splendid value for the price (8*s.* 6*d*), and I have never met such a book in the German language; owing, however, to its foot pound system half of the value is gone for me.

You export much to the smaller countries and other countries in Europe, South America, &c., and if you would send your technical books in C.G.S. system and charge a normal fee for your colleges, many more engineers, who, after all, order the stuff, would get to know your firms thoroughly, and then the case is half won already. *Rs* prices; this, of course, is a question of tremendous branch organisation, which you have not got here at all, and of using only qualified engineers (with practical experience) where you use ex-pupils, &c., now.

Yours truly,

C. TER COCK.

2, East Side-road, Golders Green, N.W.,
April 19, 1917.

To the Editor of Engineering.

SIR,—I venture to suggest that most of the objections put forward to the metric system would disappear if it were once adopted.

Obviously the coinage, which is entirely under the control of the Government, is the first thing to alter, and the advantages accruing from a revised decimal coinage would, I believe, be so great as to reconcile almost everybody to the adoption of the metrical system for weights and measures also.

I agree with the almost universal suggestion that the pound sterling and the florin should be the main features of British decimal coinage. I suggest, however, that the five-shilling piece, the four-shilling piece, the threepenny-bit, and the farthing should go, as being entirely useless complications. The coinage would then consist of (1) the pound sterling, or ten florins; (2) the florin; (3) the shilling or half-florin.

Up to that point I believe most coinage reformers are in substantial agreement. When, however, they come to introduce a subdivision of the florin into 100 mils or cents or any other foreign coin of absurdly small value with an unfamiliar name, I think they go wrong. I have not yet heard any good reason why the copper coinage should not be withdrawn and reissued 10 pennies to a shilling, instead of 12 as at present, 20 halfpennies also being provided to the shilling, instead of 24. The sixpence, which is a really useful coin, would be retained, but re-christened and re-minted fivepence.

On this system practically no coin would require to have its name changed with the one exception of the fivepence, which would be learned by everybody concerned in a week. The coinage would be simplified to the smallest possible number of useful coins, all differing sufficiently in size and weight. The retention of the penny and the shilling in their present shape would save from the scrap heap an enormous number of coin-freed apparatus, including telephones, gas and electricity meters, penny-in-the-slot machines, and so forth.

If there were any danger of any particular interest being unduly favoured by the change in the value of the 1*d.* it could be taxed out of them by means of a special impost with the greatest of ease.

The advantage both to ourselves and to foreigners of avoiding the change in name and the change of habit involved in the use of small unfamiliar coins and values would be enormous. I am assured that the saving in labour under the proposed system to bankers, bookkeepers, post offices, and everybody else concerned in counting small sums would be extraordinary. At the same time every advantage offered by the metric system is secured.

I am, sir, yours obediently,

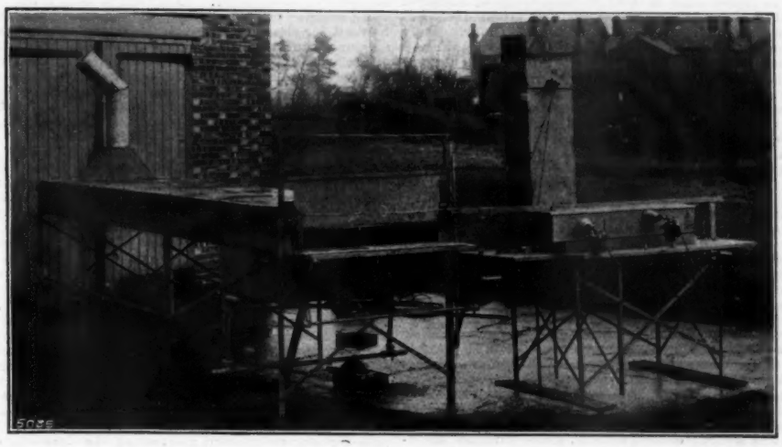
April 24, 1917. G. W.

"ACIERAL," AN ALUMINIUM ALLOY.—We read in *The Iron Age*, New York, that an alloy containing 92 per cent. to 97 per cent. of aluminium, and offered as a metal of strength and lightness, and non-corrosive, suitable for use in the manufacture of automobiles, aircraft, military equipment, hardware, &c., has been put on the market by the Acieral Company of America, 26, Cortlandt-street, New York. It is the discovery of Mr. de Montby, a Frenchman. It is being supplied, it is said, to the French Government, for the manufacture of helmets. It is silver white, has a specific gravity of 2.82 and a melting-point of 1382 deg. Fahr. Its tensile strength in castings is given as 30,000 lb. per square inch, and in rods and sheets up to 64,000 lb.; heat treated, its tensile strength is given as over 70,000 lb. per square inch. It is claimed that it may be sand cast, die cast with or without pressure, hot and cold forged, annealed, drawn, rolled, stamped, hardened by temper, polished, electro-plated and soldered. It withstands the action of all acids except hydrochloric. With aluminium at 60c. per lb. acieral in ingot form will sell, it is stated, at $1 per pound. It is manufactured in electric furnaces, and the plant, located at 20, Orange-street, Newark, N.J., has a daily capacity of 10 tons, and has been in operation for about a month and a half.

CONTINUOUS ENAMELLING AND STOVING MACHINE.

CONSTRUCTED BY MESSRS. LACY-HULBERT AND CO., LIMITED, ENGINEERS, LONDON.

(*For Description, see opposite Page.*)



PRESIDENTIAL ADDRESS TO THE INSTITUTION OF MECHANICAL ENGINEERS.*

By Mr. Michael Longridge.

It is a custom worthy of honour by observance that the president of this Institution should devote the first sentences of his address to an attempt to express his appreciation of the great honour the members have conferred upon him. It is not easy to find the right words for such a task, but if each one here will call to mind the names of our past-presidents engraved upon the marble panel in the Institution Hall, commencing with George Stephenson, who taught my father his profession of a civil engineer, and ending with William Cawthorne Unwin, whose great attainments we all recognise, and imagine how great would be his pride if he found his own name added to that roll, he will understand my feelings far better than I can express them. But pride of place and office is not the predominant element of my content. It is rather the knowledge that I have been accorded the confidence and esteem of those for whom, with whom, and even against whom, I have worked since I became a member of the Institution 37 years ago. It is for that I am most grateful. It is for that I thank you even more heartily than for having elected me your president.

I believe it has also been customary for our presidents to base their addresses more or less upon their own professional experiences, reviewing the more recent developments of those branches of mechanical engineering with which they may have been most intimately associated. Had we been living in normal times, I should probably have followed a similar course, and held forth on the changes which have taken place during my own engineering life in power plants for driving works of various kinds, especially textile mills and factories. I think the developments and inventions in connection with these during the last 50 years would have provided excellent material for a president's address.

But in the circumstances of to-day I feel that a review of this kind would excite less interest than impatience. Its scope would be too narrow. Our minds are occupied with matters of far greater moment than the developments of power plants for driving mills and works. They are fixed upon the war, and the evolution that must follow it. The war has taught us many things, but none more clearly, more insistently, than the importance of our engineering industry. Upon this industry we depend for victory to-day and for security and prosperity to-morrow. Should it be wrested from us, as many industries have been during the past half-century, England would fall to the rank of a second-rate Power and the British Empire would be dismembered. The war has made us realise the possibility of this great disaster, and has brought home to us the need of action to avert it. And the need is urgent. The victory we all pray for may be won before my successor takes my place. Then we shall be plunged at once into a commercial struggle, and, unless we adopt my old school motto, *sicut serpentes sicut columbæ*—"wise as serpents and gentle as doves"—into an industrial war also, both fiercer than any we have hitherto had to face.

America is rich beyond imagination, and is systematically preparing to capture the world's markets if she can. Germany, if reports be true, is organising her industrial resources in a way that we, with our strongly individualistic proclivities, cannot hope to rival. Neutral nations are growing rich at the expense of those who are fighting for their future independence. It therefore behoves us to take stock of our position and plan measures, not merely to hold our own, but to regain the pre-eminence which British manufacturers have lost. Why was that pre-eminence lost, and how can we regain it? These are the questions which interest mechanical engineers beyond all other questions at the present time. And so I am tempted to speak about them, when, perhaps, silence would better become my inexperience, for I am neither a merchant nor a manufacturer. I shall ask you, therefore, to look back for a moment on the past, to view it from the standpoint of to-day—the retrospect may give some clue to the causes of our failures—and then I want to mention some of the things which we have done to repair our losses and some of the many we have yet to do. I do not wish to dogmatise, but rather to suggest.

When our Institution was founded in 1847 mechanical engineering, together with the other industries it served, was rapidly acquiring that pre-eminence which was soon to earn for England the title of the workshop of the world. The mechanical engineer was favoured by circumstances of time and place. The country's natural wealth in coal and ironstone had supplied him with the raw material of his trade. The improvement of the steam engine by James Watt had given him power to drive his works. The evolution of the locomotive and the railway by George and Robert Stephenson had provided cheaper and more rapid means of internal communication than were available elsewhere. The application of steam power to navigation initiated earlier in the century by Robert Fulton and Henry Bell, the numerous harbours on our coast, and the protection of a Navy supreme upon the seas, facilitated and safeguarded trade abroad. Finally, the abolition of the corn laws, if it devasted agriculture and hazarded the safety of the nation, undoubtedly assisted the mechanical engineer, first, by driving the rural population to the towns and thus providing labour for the workshop, and, secondly, by enabling foreigners to become his customers by paying for his productions with their corn. The extraordinary expansion of the cotton trade following the inventions of Hargreaves and his fellows, and the substitution of iron for wood in shipbuilding, also brought no small prosperity to the mechanical engineer. With such advantages it is not surprising that before our Institution came of age England had won the title she has now for a long time lost.

In winning this title she was transformed from an agricultural and practically self-supporting nation into a manufacturing community dependent for its existence, as we realise too well to-day, upon imported food.*

And as the mechanical engineer was responsible in no small measure for the transformation, so he must be held responsible for the maintenance and efficiency of the workshop on which the feeding of the people and the defence of the people against their enemies now depend. He became and he remains a trustee for the British Empire. How did he discharge the trust? By humbly seeking knowledge to turn the gifts of Nature to the use of man? By invoking the aid of science to develop the discoveries of the men who had prepared the road to his success? By caring for the welfare of the thousands who were spending their waking hours in his factories? By giving them a fair share of the profits of his business? I think we have the grace to-day to answer NO. I think we are willing to confess that our heads were turned by elation at our prosperity, that we were obsessed by admiration of our own achievements; too confident of the sufficiency of our limited knowledge; too contemptuous of the few who tried to throw the light of science on our path; too eager for wealth, and the social influence wealth could buy in the new state of society; too careless of the needs and aspirations of the "hands" who helped to make the rapid accumulation of large fortunes possible.

And what has been the consequence? For every lapse from the ideal, and there is an ideal even of industrial policy, Nemesis Adrasteia sooner or later enacts retribution.

Let me unfold the story of the engine-building trade of Lancashire. There was a time when shops were many and full, when Lancashire steam engines were sent wherever steam engines were used, when Lancashire's supremacy in this branch of engineering was beyond dispute. In 1900 I went to the Paris Exhibition. I went there primarily to see the stationary engines, whose claims in the matter of steam consumption were beginning to attract attention here. What I saw there "gave me," to use a French expression, "furiously to think." I received a revelation. In elegance of form, in completeness of finish, in careful arrangement of details, the engines exhibited by some of the Continental makers excelled any I had seen before. The British stationary engines, small in size and number, slovenly in finish, makeshift in the fitting of accessories, such as cylinder clothing, lubricating apparatus, wheel guards, savealls and the like, and sadly lacking in artistic inspiration of design, proclaimed to seeing eyes the dangerous excellence, not to say superiority, of the foreign work.

Ominous as the exhibition was, it failed, so far as I could see, to produce any important changes in the practice of British engine-building firms. Nor is this very surprising. Those in authority in the drawing offices and works were still men trained exclusively in the shops. The "product of the technical school" was still widely held to be a useless, if not a noxious product, and perhaps in the early days of technical education his training did not make for easy correspondence with his new environment. At all events, he had not yet acquired any effective influence in current engineering practice or design. The consequence was that when, as time went on, repeated loss of orders forced British engineers to recognise the estimation in which Continental work was held by customers, royalties were paid for foreign patents, foreign draughtsmen were employed, and foreign drawings bought. And, later still, to fill up the cup of our humiliation, complete steam engines built abroad were brought to England, erected and set to work by foreign workmen, not only for public bodies, which thereby justified the gibe about their lack of souls, but in the very home of British steam engine manufacture, in Lancashire itself.

In the meantime British engineering firms, whose names were household words, were being wound-up, or ceasing to be dividend-paying concerns.

In some cases the inducement to buy abroad was lower price, in some earlier delivery, in some convenience of collaboration with makers of electrical machinery; but perhaps in most it was a guaranteed rate of steam consumption which could not be obtained at home. In either case we ought to have been able to offer the inducement here. It is entirely our own fault that we could not.

In the nineteenth century few British engineers were able to guarantee the steam consumption of their own steam engines. To-day most contracts contain consumption guarantees. If these guarantees are not so low as those obtainable abroad, I think their fulfilment sometimes falls less short of promise.

I have taken my illustration from this particular branch of engineering, not because it was specially conservative, but because many of those interested in it are my friends and know that I speak from conviction, not from malice. I believe that most other branches of mechanical engineering have suffered more or less from foreign or American competition. Some of the causes of our relative retrogression are beyond the control of engineers, others they can remove in part or altogether, and of these I think inefficient technical education, lack of trade organisation, and the policy of the trade unions, claim special attention.

Technical Education.—In the early days of our Institution most engineers were trained entirely in the shops. Theoretical knowledge was uncalled for, and even held to be antagonistic to practical success. There was no supply of scientific engineers, partly because there was no demand, and partly because the places where a man could study the theoretical side of his profession were few and far between. It was only in 1840 that the chair of engineering, subsequently filled by Rankin, was established at Glasgow University. There were engineering courses in London at King's College, and courses dealing more particularly with mining and shipbuilding at the School of Mines and at the School of Naval Architecture. In the provinces there were a few technical colleges, such as the Merchant Venturers' Technical College at Bristol and the Owens College at Manchester, though it was only in 1868 that the first professor of engineering, Osborne Reynolds, was appointed there. In the great centres of the iron and engineering trades opportunities for technical education, beyond what might be acquired in mechanics' institutes, were practically non-existent.

It was not till 1877 that the livery companies of London, belying the popular idea of their activities, appointed a committee to consider the possibility of initiating a national scheme of technical education. The City and Guilds Central College was the result. Its foundation in 1880 marked the first public recognition of the need of something more than office or workshop training for the engineer. Then came the appointment of the Royal Commission, which reported in 1884, the formation of the National Association for the Promotion

* Delivered on Friday evening, April 20.

* Wheat consumption of the United Kingdom :—

Year.	Home grown. Quarters.	Imported. Quarters.
1842 ...	22,000,000	... 2,970,000
1914 ...	7,300,000	... 29,220,000

of Technical Education in 1887, and the Technical Education Act of 1889, which refused to the schools it governed the means of teaching the practice of any trade. In 1890 only was a real foundation laid by the transfer of the control of technical education from the school boards to the local authorities, and the appropriation of half the "whisky money" for its support.

The result has been a vast expenditure on technical schools. Nearly every local authority has built one. These schools range from the technical school of the small borough, whose engineering instruction is limited to evening classes in "engineering drawing, practical mathematics, and" (I quote from the prospectus of one of them) "engineering science," whatever that may be—they range from such schools to institutions of university rank like the Municipal School of Technology in Manchester, with its numerous laboratories, and among them engineering laboratories and workshops equipped with full-size modern machinery, tools and apparatus, not only of the types in general use, but also others specially designed for demonstration and experiment, where the science of engineering and the outlines of its practice can be learnt, and where research is carried on by professors of high attainments and post-graduate students in connection with the workshops of the district.

Besides these we have provided engineering courses in most of our older universities, and endowed new, where science enjoys more prestige than Greek. To Oxford, Cambridge, St. Andrews, Glasgow, Aberdeen, Edinburgh, Dublin, Durham, London, we have added, since the foundation of this Institution, Manchester, Wales, Birmingham, Liverpool, Leeds, Sheffield, Bristol, Belfast, and the National University of Ireland.

With all these schools and colleges it might be thought that the problem of educating engineers and engineering workmen had been completely solved. Unfortunately it has not. Our innate conservatism ties us too much to the traditions of the past. Many still fail to understand that the manual training which enabled an apprentice to become a master craftsman in times gone by does not suffice to turn a schoolboy into an engineer to-day. The functions of the engineer and craftsman are entirely different, and their training must be different also. Moreover, differentiation is needed in the training of the various classes of engineers and workmen. Designers and scientific advisers require a knowledge and experience which managers and business organisers can forego without much disadvantage. Foreman and supervisors similarly need a wider range of practical experience and technical knowledge than men destined to be manual workers all their lives. This lack of differentiation seems to be one cause of the inefficiency of our technical education relatively to its cost. Another certainly is insufficient preparation of those entering the technical schools.

On the whole the education available for the higher ranks seems fairly satisfactory; at all events, it has produced men capable of solving many of the new and difficult technical problems presented by the war. Yet, on behalf of these, I would give one caution and make one complaint. There are many Englishmen of the best type with initiative, ability to organise, and power to lead and manage men, yet really incapable of assimilating much book learning, especially higher mathematics. Do not let us make the mistake of forcing these men through the same collegiate course as men of different mentality, and then passing them on examination with a low standard of full marks. It would be infinitely better for everybody to keep them to more elementary work and require a high standard in examination. We must not underrate these men in our newborn zeal for scientific formulæ. Many of them are of our very best. The institution recognises their value by admitting them without examination at 30 years of age. I hope the rule will not be altered. It is astonishing how much sound engineering can be done with the aid of $s = vt$, $v^2 = 2fs$, $P = mf$, &c., and corresponding elementary relations in other branches of natural philosophy, if only their meaning be well rubbed in and their application clearly understood.

And my complaint. It is against the obstinacy of our two most famous universities in retaining Greek as a compulsory subject in their examinations.* This reacts upon our public schools, and is a serious handicap on those who, intending to deal with the concrete rather than the abstract in their future lives, yet wish to find their level in the social life and moral discipline of these two universities. The English public school boy can generally be relied on to face difficulties, lead men and keep his hands clean in business. Engineering cannot afford to lose him to satisfy the country parsons who rule Oxford and Cambridge in this matter.

The education provided for the workmen, on the other hand, both general and technical, is most unsatisfactory. Trade apprentices who enter the shops at 14 years of age, and sometimes earlier, seldom have subsequent opportunities for learning other than at evening classes. Some are resolute enough to attempt brain work at the end of a day beginning between 5 a.m. and 6 a.m., and some are strong enough to profit by their attempt. The majority are not. I have seen in some paper that technical education in England and Wales is provided in 6,876 evening and similar schools, but that the average attendance is about one hour per week. Whether the average for engineers is greater or less I do not know.

In parts of Scotland continuation schools are provided in connection with the industries of the districts, and parents and employers are compelled to send young people to them during working hours between the ages of 14 years and 17 years. In England the difficulty is overcome in some large works by allowing promising boys to spend some of their working hours at technical schools without loss of time or pay. In others, technical instruction is given in the works. Unfortunately British engineering works are generally too small, and the managers too unwilling to co-operate with each other, to allow such arrangements to become general. Yet the workman must have better education to qualify him to rise if capable, and to give those who have not the ability to rise some interests outside their daily work and football matches; and also to lessen drunkenness. The need will become greater as repetition work and automatic machinery replace varied jobs and manual skill. Unless an antidote be provided, the monotony of this kind of work will crush initiative and mental vigour, and instead of skilful workmen we shall breed incompetent machines. I have been told that there is more discontent among minders of automatic machinery than among men who have to use their brains and hands, and I can well believe it is so. Either the age for leaving school will have to be raised or some scheme devised for combining technical instruction (not mere craftsmanship) in the works, with general instruction in the schools in working hours—unless engineering employers refuse to take lads into the works till they are 15 or 16 years of age. Apprentices entering works from the junior technical schools at 15 or 16 will be better workmen at 21 than those entering at 12 or 14 from the elementary schools.

I think, also, that a clear distinction should be made between technical colleges of university rank on the one hand and senior technical schools, whose entrance standard is lower than university matriculation, on the other. The interests of engineers require two classes of institutions giving technical instruction, each with its definite purpose:—

(1) Technical "colleges."
(2) Technical "schools" (senior and junior).

The technical "colleges" should be of university rank, and should be departments or faculties of universities, like the Municipal School of Technology in Manchester, not independent of them, as in Germany. They should provide two courses, one for the scientific advisers and designers, the other for the managers and business organisers. They would receive their students mainly from the higher secondary schools. Admission should be by examination, or very strong recommendation by qualified persons in the case of men past undergraduate age. The gate should be opened only to those capable of profiting by the teaching. The idea of university education for the million is most pernicious nonsense.

The reason for making these schools departments of the universities is that the connection would prevent overlapping of teaching, and would ensure that uniformity in examination standards which some of the universities are trying to bring about. By uniformity of examination standards I do not mean uniformity of technological teaching. In this respect some diversity, and some degree of specialisation, would be desirable.

The technical "schools," both the senior, and the junior which are frequently housed with them, should also have two courses, one suitable for men likely to become foremen or supervisors, the other for those likely to remain manual workers. These courses should not be purely technical. The schools would receive their students from the elementary and lower secondary schools. They should remain under the local authorities, so that the technical teaching might be varied in accordance with the local trades.

Another desideratum is co-ordination of the work, especially between the higher secondary schools and what I have called the technical colleges, and between the elementary and lower secondary schools and what I have called the technical schools, so that pupils passing from the one to the other would be properly prepared for the change. We also need a uniform system of adequate scholarships, to enable the best intellects among the poor to go up the whole educational ladder and mix on equal terms on each rung with those better endowed with this world's goods. The number and values of the scholarships available depend at present too much upon the ideas of the various local authorities.

Organisation of Engineering.—And now I must pass on to my second point—organisation, or, rather, lack of it. Mechanical engineers are broadly divided into two classes—manufacturers and consultants. The latter, I believe, consider themselves the superior class, because they have been able to impose their wills and specification on the manufacturers. They can do so still to some extent. In the future they will do so not at all.

There was a time when the consulting mechanical engineer sent out his own drawings, and the manufacturer had to work to them. Now the engineer sends out his specification, but the manufacturer makes his own drawings and works to them, or offers some standard article complying more or less with the specification of the engineer. To-morrow the engineer will merely describe the work the machinery he requires will have to do, and witness the tests of its performance. Some day he will become a mere inspector, the manufacturer supplying the scheme and the machinery required for its working from his own designs. I think this will be the inevitable result of giving men of science and high technical ability their proper places in the works; if so, the profession of consulting mechanical engineer will not be as lucrative in the future as it has been in the past.

But if manufacturers wish to be freed from interference of consulting engineers with their designs and processes, they must give their customers full information about the machinery they tender for. Their specifications are often extremely vague. The specifications of engine-builders, for instance, are filled with such phrases as "great strength," "ample bearing surface," "best materials," "highest class of workmanship"—none of which conveys the slightest meaning to the customer or his engineer. *They* want to know the stresses and pressures per square inch allowed, the materials to be used for the various parts, which surfaces are to be machined, and what tolerances are allowed. For lack of information of this kind I have been compelled to make acceptance of tenders conditional upon the supply of a complete set of blue prints for examination, and upon consent to alter them at my request. All this involves expense, irritation, and serious risk of error. I think it would be better if all engine-builders built their own standard engines, as some do now, and refused to alter them, but gave each customer a complete set of blue prints—as very few do now—marked (not necessarily with dimensions), but with stresses, loads, materials, and machining. If the engines were built on a proportional system, one set of prints, though necessarily not to scale, would serve for a whole series. The customer would then see what he was going to buy, and the engineer could "manufacture" instead of building each engine to a special design. Thereby much trouble and expense would be avoided.

The objection has been raised that if A sent out his drawings, B could copy them. Well, what if he did? A could copy B, and both would be gainers by exchanging their ideas. Else why does the Institution of Mechanical Engineers exist? I can remember when engines were built with strokes of 6 ft. and ¼ in., and screws were cut with fancy threads to keep the repairs in the builder's shop. What folly it all seems now. What folly this plea for secrecy in such matters as the drawings of a steam engine will seem in a few years' time. The secret of success in mechanical engineering lies, in these days of technical education, in quality and treatment of materials, accuracy of machine tools, and skill of workmen, not in drawings.

I have been led into this digression by reflecting on my own experience. I return to the more general question of organising the engineering trade both in its individual workshops and as a whole.

Except in a few cases, workshop organisation here has not received the attention given to it in America and Germany. There are still shops without definite planning of the progress of the work, without adequate equipment of jigs and gauges, and without standard shapes of tools or a tool room; where men drift about in search of tools and tackle or wait in idleness for drawings or materials, where machinery is obsolete, and light so bad that good work could not be done if the machinery were up-to-date.

Such shops will have to go. They cannot compete in price or quality of work with those where what is known as "scientific management," or anything approaching it, prevails; where the progress of every job is planned to the last detail before it is sent into the works; where machinery is so arranged that each piece passes through the whole series of operations to be performed upon it in predetermined order and without pause, and is immediately succeeded by another piece to undergo the same cycle of operations; where labourers and tackle for fixing the work in the machines are ready the moment they are wanted; where drawings, gauges, tools properly ground to standard shapes come with the work; where cleanliness, light, and comfort reign, and where endeavour is made to get the workman to regard his work more as a problem to be solved than as a task to be got through.

And if the industry is insufficiently organised in machinery and shop management, it is still more so in the equally important business of obtaining orders to keep the shops at work. There are no central selling agencies like that of the great thread "combine." Each firm has its own agents. Many of those working in England have little or no engineering knowledge, and those working abroad are often without the social influence and powerful diplomatic and financial backing of their competitors. We are far too much inclined to look upon the commercial representatives of engineering firms as "bagmen." I have been humiliated and indignant at the supercilious discourtesy or downright insolence with which I have sometimes seen these men received, even by engineers. While they are treated in this way the right class of men will never enter this branch of the engineering industry. To represent the industry abroad we need cultivated men as well as technical experts, tactful diplomatists, masters of other languages than their own, and the social equals or superiors of those they may have to transact business with. Small firms cannot afford to employ such men any more than they can afford to keep their machinery up-to-date, or to refuse orders for goods which their machinery is not specially adapted to produce, to provide instruction for their apprentices, to pay for scientific assistance, or to undertake experiment and research. For these and other reasons there is not time to explain now some kind of combination or co-operation among engineering firms, especially the smaller firms, seems very desirable, if not indeed essential.

Combinations have been arranged in other trades. The Fine Spinners and Doublers' Association, Associated Portland Cement, Limited, Wall-paper Manufacturers, Limited, United Alkali, Limited, the North British Locomotive Company, are examples. None of these except the last is engaged in engineering, but they may be used as precedents to overcome the objection to development, the *omne ignotum pro horribile* sentiment

* There is some hope that compulsory Greek will be abolished. Addressing a recent conference of the Educational Association, no less a personage than the Master of Balliol is reported to have said: "The movement to take in natural science was not hostile to the older subjects; he was quite sure that the opinion in his college and widely diffused through the university was that there was room for the two, and that a great deal of the old curricula might with advantage be dropped to allow new inspiring subjects to come into university education."

which is so ingrained in the English character. In Germany, I understand, the dye trade, and all the trades ancillary thereto, have just been combined into one vast concern, with a capital of 800,000,000 marks. The great and powerful combinations in the steel trade in America and Germany cannot be ignored. The industrial world does not stand still. Similar combinations among engineers will have to be seriously considered. The Socialistic ideal of Government control and ownership, though it may in some degree be necessary to carry an unprepared, unorganised nation through a great war, will never commend itself to the people of this country. Mechanical engineering to be efficient must be independent, and to be independent it must have some powerful representative body to decide and voice its policy. Much thought has been, and is now being, given to the formation and functions of representative trade associations, and several such associations have been formed directly or indirectly connected with mechanical engineering. It is sufficient for my purpose to mention two of them.

First, the Federation of British Industries, the child of Mr. Dudley Docker, C.B. It is intended to represent all the industries of the country.

Second, the British Engineering Association (the B.E.A.), connected with the name of the inventor of that very efficient "strafing" apparatus, the Stokes' gun. With it is now amalgamated the Council for the Organisation of British Engineering Industries, born at the Manchester Engineers' Club in 1914. The amalgamation is intended to be representative of the entire engineering industry, just as another similar association, the British Electrical and Allied Manufacturers' Association (the B.E.A.M.A.), is intended to represent the electrical industry.

In these associations might be found the components of a practical and effective scheme for the organisation of the British engineering industry, if only it were possible to co-ordinate them, to induce all firms to belong to them, and to get the trade unions to co-operate.

For instance, at one end of the chain there might be the individual employer responsible to the District Executive of the British Engineering Association for the management of his own works, the corresponding trade union authority being the shop stewards or the men's shop committee.

The next link would be the District Executive of the British Engineering Association, with which might be amalgamated the District Committee of the existing Engineering Trades Employers' Federation. This District Executive would be charged with the oversight of the district employers, works, and trade. In co-operation with the district officers of the trade unions they would arrange rate of wages and piecework, terms of co-partnery, the number of apprentices for whom places could be found and the means of continuing their education. The District Executive would receive reports from employers as to the state of their order books, their difficulties with labour, supply of materials, and transport; also as to experiments and research required to overcome local manufacturing difficulties, and would report to the Executive Council of the B.E.A., *i.e.*, the Executive Council of the entire engineering industry. If combination or amalgamation could be arranged they would also advise the Executive Council of the B.E.A. as to the kind of work each shop in each district could profitably undertake, what machinery required replacement, what works should be removed to other districts or closed altogether; they would also keep reactionary employers in order.

The next link—the supreme body in the engineering trade—might be the Executive Council of the British Engineering Association. With it might be amalgamated the existing Engineering Trades Employers' Federation. Its proposed activities can be partly gathered from what I have just said. They are described at length in a report presented to the Council for the Organisation of British Engineering Industry at the Engineers' Club in Manchester in November, 1915. I cannot repeat them here. They include transport, intelligence, production, patents, publicity, finance, education, research, and legislation in the broadest sense. The council would act through standing committees. Its authority would be great and its influence far-reaching. The corresponding body acting for the men would be the executives of all the engineering trade unions.

Last of all would come the Federation of (all) British Industries and the Federation of Trade Unions, if that body be brought to birth. These would deal directly with a Minister of Industry and Commerce. The chain would then stand thus:—

The manufacturer.	=	The shop stewards.
The District Executive of the B.E.A.	=	The district officers of the Engineering Trades Unions.
The Supreme Executive Council of the B.E.A.	=	The Executives of the Engineering Trade Unions.
The Federation of (all) British Industries.	=	The Federation of Trade Unions.

The Minister of Industry and Commerce.

As yet there is no Minister of Industry and Commerce, but there is a Minister of Labour. Labour is a very essential element in industry. Both have the same interests. Let us not have two Government Departments to squabble with each other and accentuate the difficulties which we hope to smooth away. Let the Ministry of Labour absorb all interests and become the Ministry of Industry and Commerce, acting for the interests of employers and employed alike.

I have outlined this scheme of co-ordinated associations as a speculation. I do not suppose there is the faintest chance of its adoption. I fear that many manufacturers would oppose it tooth and nail. I have no idea how the trade unions would regard it. But even if the combination or amalgamation suggestions be deleted, there would still remain a skeleton on which a living body of some kind might be built. And here to prevent any misunderstanding, I think I ought to say that the Manchester report, to which I have referred, does not advocate a "combine"; on the contrary, it disclaims any such intention. I have suggested it myself because I cannot see that much good can be done unless at least the small firms be amalgamated. Moreover, the suggested amalgamation of the existing Engineering Employers' Federation with the new B.E.A. might not be easily accomplished.

Employers and Employed.—I have spoken so far of matters which we engineers can deal with if we will, our own education and training, the education and training of our workmen and the organisation of our industry. But now I come to a problem of far greater difficulty, the negotiation of a treaty to secure a lasting peace between employers and employed. Without this peace the victory over Germany, for which we have sacrificed so much, will be in vain. The future of the British Empire depends on its attainment.

Even if it were not so a treaty should be made. The Government and all firms working under it have bound themselves jointly and severally to restore all the trade union restrictions, rules and customs which the unions, at the request of the Government, agreed to abrogate for the duration of the war. Their restoration has been a condition in all Government contracts since March, 1915, and was guaranteed by the Prime Minister in the House of Commons in the following month.*

I hope the trade unions will have learnt, before the war is over, that a policy which compels a workman to limit his output and his earnings, which refuses a manufacturer a due return on the cost of installing up-to-date machinery, and on expenditure for scientific research, is as injurious to the workman as to his country, and that if persisted in it will ultimately ruin both, even if it bring particular unions some temporary gain. If we are to compete successfully with nations in whose industrial vocabulary "ca' canny" finds no place, limitation of output and restrictions on working machinery will have to be given up.

But if the unions be wise enough to give up voluntarily what we have undertaken to restore, we are in honour bound to give them some acceptable equivalent. I have seen in the newspapers that conferences are being held between representatives of the employers and the unions with a view to the negotiation of a treaty of industrial peace. I hope that the report is true, for I believe that more industrial disputes are caused by misunderstandings than by wrongs, and that misunderstandings most easily become understandings when men meet face to face resolved to find the "middle way."

Of the possible or desirable terms of such a treaty it is not my place to speak. But I may try to influence the spirit in which the questions at issue should be discussed and in which the inevitable difficulties of interpretation and execution of the terms agreed on should be faced. I want it to be a spirit of sympathy and great forbearance. I know that I am asking much. The strikes, the deliberate limitation of output by some men, the bargains driven with the Government in the hour of the country's direst peril, have roused an indignation difficult to control. I ask for sympathy and forbearance nevertheless. I think that many of the men, and of their leaders, have done their best in very difficult circumstances, and where they have been to blame, I think, before passing judgment, we should consider how far we are ourselves responsible for the conduct we so bitterly condemn.

For 100 years employers and employed have been at war, and war leaves bitter memories. The war began when the tools of his trade were transferred from the workman to his master and he became dependent for permission to use them on his master's will. In 1817 trade was bad and employment difficult to obtain. The country was exhausted by the Napoleonic Wars. Food was scarce and dear. Wages were low and largely paid in goods sold in the masters' shops and at the masters' prices. Children of tender age were driven to labour in the mills.† Houses and factories were insanitary, and many trades were deadly to the workers. There was no legislation to guard life or limb. When men were killed in collieries no inquests were held. Ignorance was dense. Thousands could neither read nor write. The only schools for the people were the Church of England parish schools. Travelling was difficult and costly. Means of finding employment or learning rates of wages and conditions of labour outside a man's immediate neighbourhood were beyond the workman's reach.

Nor was his material condition the sole cause of the workman's discontent. The law forbade him to improve his lot. In 1817 "any persons combining with others to advance their wages or decrease the quantity of their work, or in any way affect or control those who carried on any manufacture or trade in the control or management thereof, might be convicted by one justice of the peace, and might be committed to the common gaol for any time not exceeding three calendar months, or be kept at hard labour in a house of correction for a term of two calendar months."

Is it astonishing that men, bred up in ignorance and deprived of free speech by law administered by their oppressors, were driven by anger and despair to violence? Indeed, the injustice of the law was so apparent that a Select Committee of the House of Commons reported in 1824 that the existing law had not only not been efficient to prevent combinations either of masters or workmen, but on the contrary had, in the opinion of both parties, had a tendency to produce mutual irritation and distrust, and to give a violent character to the combinations, and to render them highly dangerous to the peace of the community. The Committee also expressed the opinion that masters and workmen should be freed from such restrictions as regarded rates of wages and hours of working, and be left at perfect liberty to make such arrangements as they mutually thought proper; and they recommended that the statute law, which interfered in this particular between masters and workmen, should be repealed, and also that the common law, under which a peaceable meeting of masters or workmen might be a ground for prosecution, should be altered.

An Act giving effect to these recommendations was passed in 1824, but was repealed in 1825, because, as the preamble of the repealing Act set out, such combinations as were legalised by the Act of the previous year "were injurious to trade and commerce, dangerous to the tranquillity of the country, and especially prejudicial to the interests of all concerned in them."

Such was the oppression and injustice under which the workers toiled and the masters made their fortunes when our grandfathers were young; yes, and also when the present workers' grandfathers were young, and the grandsons have heard, and have not forgotten the tales of their grandfathers' young days. The first Truck Act forbidding payment of wages in food, in drink, in clothes, or articles other than current coin, and making illegal all agreements as to where the money should be spent, was only passed in 1831. Nor has it been forgotten that, with the exception of a few men like Robert Owen and Michael Sadler, employers as a class for many years consistently opposed all legislation making for the health and safety of the workers. The workers know, too, that some employers refuse to recognise the unions even now.

That the unions have roused hostility by the intolerance of some of their officials and by their selfish economic policy is unfortunately true. But in our attitude towards them we should not forget that intolerance is the natural reaction of inexperienced youth in possession of unlooked-for power against past oppression and injustice, or that an unwise policy is the fruit of ignorance. The A.S.E., one of the oldest of the trade unions, was only founded in 1851. The first Elementary Education Act was passed in 1870.

Employers should also consider how far limitation of output, and objections to piecework profit-sharing and co-partnership, two of the most serious causes of difference with the unions, are due to their own short-sighted policy in cutting piecework rates. The case has been very plainly put by Mr. Barnes, M.P. "The system," he says, "has been a failure because, in the stress of competition, piecework earnings have tended to slide downwards to what previously had been a time-work wage." Indeed, it would almost seem to have been an article of economic religion that a workman's earnings should be limited by precedent. And thus we go on in a vicious circle, the master unable to increase wages because the workman will not give the necessary output, the workman limiting the output because the master does not raise the pay.

But that is not the only reason why the workman limits output and refuses piecework. Deeply in his mind is rooted the belief that increased output causes glutted markets, short time, and unemployment, a terror which casts its shadow over his whole life. This delusion can only be removed by education.

I have said all this not to raise prejudice against employers, but to show the ground on which I am appealing for understanding and forbearance in the great effort which I hope is to be made to root out the suspicion and ill-will which, before the war, was settling as a deadly blight upon the industries of England, and is even now weakening our fighting power. We have to convince the workers by experience, and teach them by education, that piecework, co-partnery, and large output are to their advantage, and that only by putting the best machinery to the best use can high wages, relatively to the cost of living, be maintained.

To-day they are getting an object lesson which they must not unlearn through any act of their employers. The Prime Minister alluded recently to the subject in the House of Commons, and his words should be marked, learnt, and inwardly digested by employers and employed alike:—

"I am convinced," he said, in connection with shipbuilding, "after a great deal of examination of the problem, and hearing what has been said by both

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* On June 23, 1915, Mr. Asquith said: "We promised we would give a guarantee that at the end of the war the pre-war conditions would be restored. We have done it not merely by solemn declarations on the part of the Government, but we have embodied them in an Act of Parliament. We have a statutory guarantee carried unanimously by Parliament by men of all parties—all sorts and conditions of men. They are all in it and they are all committed to that guarantee."

† Extract from a protest against child labour in 1816. "Seven years is the earliest age at which children ought to be employed in factories, and then only for 4 or 5 hours per day. At eight or nine years of age they might be employed for 6 or 7 hours, afterwards they might be employed 10 hours, and beyond there should be no increase of labour."

employers and working-men, that the output can be considerably increased by an alteration of methods. Wherever payment by results has been introduced there has been an increase in the output of shipbuilding yards, sometimes by 20, sometimes 30, and sometimes even 40 per cent. We have made a special appeal to the great trade unions concerning shipbuilding to assent to the introduction of these methods. In some yards they have already been introduced. I was very glad to get a telegram from Liverpool stating that the Liverpool trade unions had agreed to recommend to their workmen that that course would be pursued. It also involves an undertaking on the part of the employer that if large wages are made by men as a result of special effort no advantage must be taken of that to reduce the rates, and I am perfectly certain from what they told me that they have no intention of doing anything of the kind. And if they do I want them to feel that not merely the Government would deprecate, but the House of Commons would be behind the Government in deprecating, any attempt to penalise the good worker by reducing the rate of payment. *That has been the great folly of the past, and that is why the fear of these piecework rates has simply bitten into the workmen's mind.*"

The italics are my own. And here I venture to interject a timely caution. Directly the war is over the engineering trade will have a period of activity without precedent; wages will, if possible, rise, and enormous profits will be made. These profits must not be distributed in inflated dividends, as in the "boom" after the Franco-Prussian War, first because large dividends will encourage speculative enterprises, whose failure will hasten and accentuate the financial stringency and bad trade which must come when the first great boom has to be liquidated; and, secondly, because the money must be saved to keep up wages and employment when the bad time comes and the employers' theory of piecework is put to the test.

To-day piecework prices are fixed in some places by associations of employers and employed, but generally, I think, the former have had and still have the business practically in their own hands. In the future I hope that not only piecework rates, but wages, demarcation, and other contentious questions, will be settled jointly by one or other of the associations I have mentioned. Surely with such an organisation, managed in its higher courts by men of ripe experience and ability, it would be possible to arrive at just decision and to control the headstrong and unreasonable among the employers and the men.

Then there is another matter which will have to be considered soon—the length of the working day. We ask for better education of the workers. We mean to try to give it them. But to enjoy its fruits they will demand more leisure, and I think public opinion will uphold them. The eight-hour day has been proposed and tried, and if the unions will allow the men to do their best it may be possible, even in the face of the coming competition, to keep wages up, in spite of the shorter working hours. It must be remembered, however, that in the engineering trade standing charges and interest on cost of machinery amount to several times the wages bill, and that many of these charges run on while works are standing idle, adding to the cost of every article produced and reducing the margin available for increasing wages.

Would it be possible to introduce a two-shift day? A morning shift, and an afternoon and evening shift, by which the men would get one fortnight free mornings; the next, free afternoons; every day their cherished midday meal; and every night in bed. A three-shift day is worked at greater inconvenience, but having regard to the present attitude of the unions, I fear the suggestion is outside the region of practicable politics for the present.

It is, perhaps, worth while mentioning that the three great disputes in the engineering trade were concerned with one or other of the subjects I have mentioned; qualification of men to work machines, hours of work, and limitation of output. The objects and results of these disputes are worth consideration.

The lock-out of 1852 was brought about by a demand for the abolition of piecework and the removal of labourers from machines. The masters were victorious.

The strike of 1871 was caused by the refusal of the employers to grant a fifty-four hour week. The men won.

The lock-out of 1897–1898, though it began with a strike on the question of an eight-hour day, was really brought about by interference of the unions with the management of the works, the selection and training of machine workers, objections to the employment of non-unionists; but, above all, by limitation of output. The men were beaten.

In the first and last public sentiment and right were with the masters, in the second, with the men. I shall be told that the issues of these disputes were governed by the state of trade. And so they may have been in part, but I believe there is a power that works unceasingly through right and wrong to weave the tangled web of anarchy into the pattern of an ordered life, and that these ephemeral troubles are but means that it employs to lead both sides to a right conception of their duties to each other. That this enlightenment will come is sure. The ignorance of men, their prejudices and their greed, alone postpone its advent. The masters who sweat workers, cut piecework prices, use obsolete machinery, crib time, and limit their care for health and comfort to the minimum requirements of the Factory Acts or less—the workmen who deliberately lose time and limit output, who refuse to allow machinery to be worked by men as competent to work it as themselves, who obstruct the introduction of new methods and new processes of manufacture—if we could ship them, one and all, to Germany to assert their "rights" against each other on a foreign soil and under Prussian discipline; or, better far, if we could lead them side by side in mutual trust to bury strife, suspicion, and ill-will, deep in the graves of their sons and brothers who have fallen in the war, and teach them to see the right as clearly as their dead sons and brothers see it now—the ideal of industrial life would be in sight.

It is to this end that I plead for understanding and forbearance from employers. You cannot drive 2,000,000 trade unionists, but you can educate and persuade them. "In a national crisis men should think more of what they could give than of what they were likely to get," said a great labour leader to the Manchester Trade Union Congress only three months ago. Can we not act upon his words—the time is ripe? We stand to-day upon a peak of circumstance uplifted by the war, our eyesight cleared by common peril, our sympathies unsealed by common pain. Behind us are the dark days of the past, before us on the far horizon is the new industrial world. Can we not turn our backs upon the night and march in faith, in hope, in charity, towards the dawn—the dawn of a new day when England shall be Merrie England in the noblest sense, wherein employer and employed shall live in peace and work together for the glory of their native land?

FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several foreign engineering projects, taken from *The Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Department, Board of Trade, 73, Basinghall-street, London, E.C. 2.

Italy.—H.M. Ambassador in Rome has forwarded a copy of a notice, issued by the Italian Ministry of Agriculture, fixing rules whereby agricultural bodies and societies in Italy may obtain a Government contribution towards the cost of acquiring tractors for mechanical ploughing. The grant will be conceded to these bodies up to 30 per cent. of the total cost. This figure may be increased to 40 per cent. in the event of not less than five tractors being employed in any one province. In the case of private persons the grant will not exceed 20 per cent. Agrarian Credit Institutions are asked to facilitate the acquisition of tractors by means of credit operations.

Venezuela.—H.M. Vice-Consul at Caracas reports that an agent in that city is desirous of obtaining the agency of a United Kingdom firm of manufacturers of well-boring machinery suitable for artesian and other wells. The Vice-Consul adds that there is doubtless a good opening in Venezuela for an inexpensive and handy well-boring apparatus, as there are large tracts of country which suffer much from drought during many months of the year.

Brazil.—The *Diario Official*, Rio de Janeiro, publishes a Decree (No. 12,396) approving a project for the construction of the section of the Therezopolis Railway between Varzea and Venda Nova, a distance of 22 km. 772 m. (about 14 miles). The estimated cost of the work is 2,607,205 milreis (about 130,360*l.* at current rate of exchange).

TANK STEAMERS.—There are at present 75 tank steamers, of an aggregate tonnage of 375,859 tons, in course of construction in the United States. The Standard Oil Company has 15 tank steamers ordered, the Dahomey concern 7, the S.O. Company, of New York, 5, the Atlantic Refining Company 5, and the Texas Company 7.

AGRICULTURAL MACHINERY AND IMPLEMENTS IN USE IN PALESTINE.—H.M. High Commissioner in Egypt has forwarded a memorandum prepared by the Arab Bureau on the subject of agriculture and supplies in Palestine, of which the following abstract is given in *The Board of Trade Journal*:—In the neighbourhood of Jerusalem a good deal of scientific dry farming is carried on, the ground being kept loose by continual tillage. The Arabs do not use harrows, but the Jewish colonists have introduced the harrow and American pulverisers, with very beneficial results. The ploughs chiefly in use in Palestine are the primitive Arab plough, and the German ploughs used throughout the Jewish and German colonies. British ploughs are said to be too heavy and the shape not quite suitable. In the orangeries and other plantations American ploughs are used exclusively, and American zig-zag harrows are also employed. The use of the American disc harrow is common, and American harvesters are in fairly general use even among the Arabs, whilst the Jews employ American binders. A hoe made in Philadelphia has been fairly widely introduced, but sowing drills are rare. In the Jaffa orange district the irrigation of the new grooves is effected by means of pumps operated by oil engines, which were first introduced by the Jews. Most of these engines are of British make (3 hp. to 8 h.p.), and it is estimated that there are about 300 of them in the orange groves. There is a great shortage of spare parts. The water is raised by small-bore (4 in.) tubes sunk vertically into the sand strata to a depth of between 40 m. to 60 m., the water rising to a height of 12 m. in the pipes. The pumps raise from 25 cub. m. to 40 cub. m. per hour. A grove of 20 acres is the minimum economic size for a separate pumping plant. In 1915 the above-mentioned engines were transformed into charcoal gas engines, as no supplies of oil were available. Of the pumps employed from 80 per cent. to 90 per cent. are of local manufacture, mostly at two factories in Jaffa (one of which is German and the other Jewish), where there are a number of good Jewish mechanics. (Metre = 3.28 ft; cub. m. = 35.31 cub. ft.)

CATALOGUES.

The British Machine-Tool Industry.—A pamphlet coming from the Judson-Jackson Company, Limited, of 60, Marsham-street, Westminster, is, in substance, a reprint of a lecture, delivered by Mr. Judson at Keighley, on "Trade After the War." The burden of his remarks was that British machine-tool makers were behind the times, and that they should specialise and co-operate.

Oxy-Acetylene Apparatus.—Messrs. Perkins and Co., Limited, of Junction Works, Whitehall-road, Leeds, have sent us an outline list of oxy-acetylene apparatus, such as generators, flare-lights and blow-pipes. The generators are so designed, with two carbide containers, that they can be operated continuously and, incidentally, require very little attention.

Small Electric Motors.—A list just issued by the Swedish General Electric, Limited, of 5, Chancery-lane, London, W.C. 2, shows that this company has quite a considerable stock of small D.C. and A.C. electric motors in stock in London. They range from $\frac{1}{12}$ up to 5 h.p., and cover a wide range of voltages and periodicities. Prices are not given in the list.

Tool Lubricants.—A leaflet sent out by the Judson-Jackson Company, Limited, of 50, Marsham-street, Westminster, London, S.W., advocates the use of the "Dubblejay" cutting compound for lubricating and cooling cutting tools. It is claimed for this material that it will not cause rust, gum up slides or choke pipes, while it is preferable to oil in that it does not give off objectionable fumes when hot.

High-power Electric Fittings.—Messrs. Engineering and Arc Lamps, Limited, of Sphere Works, St. Albans, Herts, have sent us a list of fittings specially designed to accommodate half-watt, nitrogen-filled lamps for industrial lighting purposes, and fitted, if it is so desired, with cut-out and substantial resistances. Another leaflet illustrates a device for preventing the "flex" used with electric irons—and similar appliances—from becoming kinked and chafed. It takes the form of a special adapter which is hung from the ceiling by means of a long helical spring.

Steel Stampings.—Messrs. Heavy Stampings, Limited, of Middlesbrough, have sent us a pamphlet illustrating some of the steel stampings which they have turned out. These include such items as motor-car axles, crank-shafts, caps for armour-piercing shells, besides quite light articles, such as steam-turbine blading. The company's equipment includes a number of drop hammers up to a 6-ton size, steam hammers and hydraulic presses. The furnaces are so arranged that they can be maintained at a predetermined temperature within very narrow limits.

Small Incandescent Lamps.—The British Thomson-Houston Company, Limited, of 77, Upper Thames-street, London, E.C. 4, have recently issued a new "handbook" of incandescent electric lamps, which is devoted to the smaller types generally employed in connection with portable batteries. Complete information is given as to dimensions, capacities, prices, &c., while a number of pages are devoted to an explanations of the terms used. Some sixteen types of lamps are catalogued, and most of these are made in over a dozen different sizes.

Semi-Rotary Pumps.—A most praiseworthy effort is being made by Messrs. Ashwell and Nesbit, Limited, of Barkby-lane, Leicester, to capture a class of business which has been largely in German hands in the past. We refer to the supply of semi-rotary hand-operated pumps. For this purpose Messrs. Ashwell have put down some special plant and are manufacturing these pumps on the interchangeable system extensively. They are of both double and quadruple acting types, and are listed in a dozen different sizes, having branches of from ¾ in. up to 3 in. diameter. The makers have just issued new price lists, which have already been translated into French, Spanish and Portuguese.

Rotary Converters.—A new publication on rotary converters has just been forwarded to us by Messrs. Siemens Brothers' Dynamo Works, Limited, of Kensington Court, London, W. In it there is a great amount of information concerning the capabilities and limitations of this class of electrical machinery in general. It is explained how it is now possible to produce a converter to operate satisfactorily on a 50, or even 60 cycle supply, whereas only a few years ago 25 cycles was considered the limit. The publication gives complete detailed descriptions of the machines, together with diagrams of connections, and is most artistically printed on real art paper. The half-tone illustrations represent converters of up to 2,000 kw. and 1,500 volts.

Colliery Engineering Pumps.—A very fine catalogue of winding, hauling and pumping engines, &c., has recently been issued by Messrs. Andrew Barclay, Sons and Co., Limited, of Caledonia Works, Kilmarnock. It contains illustrated particulars of winding engines, having drums of up to 35 ft. in diameter, which have been supplied to mines all over the world, some being simple and others compound, of both vertical and horizontal types. Details of cut-off gears, overwinding devices and brake engines are given, together with a number of illustrations of hauling engines and clutch gears. In the pumping machinery section there are included: High-pressure, centrifugal, bucket, three-throw ram, low-pressure and "Oddie-Barclay" pumps. Among the incidental manufactures referred to in the catalogue one of the most noteworthy is "Vulcanus" metal. This is used in the casting of fire bars, and it is claimed does not permit the least adherence of clinker or warping. Bars which have been in service for 20 hours per day for seven months show a loss in weight of only 4.5 per cent.